

Forecasting Significant Weather Events: Comparing Your System to Climatology

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8 August, 2002

WDTB Winter Weather Workshop
August 2002

Introduction

- **What is a significant weather event?**
 - *Definition*
 - *methodology (you want to do this too?)*
- **How to anticipate significant events:**
 - *a word about return periods*
 - *display concepts*
- **Types of events and parameters**
 - *different events appear to be impacted by*
 - *winds*
 - *moisture*
 - *thermal and height anomalies*
 - *winter storm examples/application*

Significant weather events

- **Definition:** *a significant weather event is considered to be an event where the fields, such as the height, wind, moisture, or thermal fields depart significantly from **normal**, representing “rare activity”. The latter is based on known **return periods**.*
- **Normal:** *fields depart less than ~ 1.5 standard deviations from the 30-year mean.*
- **Notes:** *some **event types** are more sensitive to anomalous winds, moisture, or thermal anomalies.*
- **NOTE:** *The impact on population, financial losses are not directly accounted for here! Purely objective.*

Historic weather events

- **Historic events:** *a unique type of significant weather event where total tropospheric anomaly of four primary variables (**MTOTAL**) departs more than 4.5 standard deviations from normal.*
- **Only 5 such events since 1948 in E. North America**
- **MTOTAL = Total Atmospheric Anomaly**
- **Explained in Methods section**

Significant QPF events

- **Definition:** *a QPF event is considered to be event where the the rainfall amounts exceeds 2 standard deviations from normal, representing “unusual activity”*
- **Key parameters (VARs):**
 - 850 hPa winds- the low-level jet concept
 - 700 and 850 hPa specific humidity-moisture for rainfall
 - Precipitable water anomalies
 - anomalous upper-level lows destabilize and relate to convergence patterns/jets.

Method

- **Climatological Data:**

- NCEP re-analysis Data 1948-2001*.
- Fixed 30 year POR 1961-1990 from re-analysis data
 - *21 day running means and*
 - *standard deviations*
- *stored in netCDF files by parameter.*
- *365 entries with mean and standard deviation*
- *March 2002 computed terrain correct Precipitable water climatology*

- **Model data acquisition**

- operational NCEP model grids
- locally generated models
- case data via Liz Page (COMET)

Method-II

- **Displays using GRaDS**

- show parameters forecast as standard contours
- display the departures of these parameters from the 30 year means, displayed as the number of standard deviations from normal, called the ***Standardized Anomaly***.
- **Real-time model data and anomalies:**
 - MRF-ensembles (<http://eyewall.met.psu.edu/ensembles>)
 - SREF-ensembles (<http://eyewall.met.psu.edu/SREF>)
 - Eta (<http://eyewall.met.psu.edu/eta>)
 - AVN (<http://eyewall.met.psu.edu/avn>)
- **Cases**
 - *climatological data only*
 - *Model forecasts with anomalies*

Computing Departures

- **Compute**

- deviations from daily normal by variable, and level

N

- vertically integrated deviations from normal of each variable

MMOIST, MTEMP, MHEIGHT, MWIND

- *Displays of Climatological and forecast fields*
 - *verse 30-year Climatology*
 - *expressed in terms of standard deviations from normal*
 - *may be positive or negative (MTOTAL uses absolute value).*

N

departure of a variable at a level in standard deviations from normal

$$N = (var_z - mean) / variability$$

where

var = (HGT, TMP, etc) *single field*

Z = pressure level (*surface, or mandatory level*)

mean = daily mean for location

variability = 1 standard deviation measure

M

tropospheric mass-average mean
departure of a parameter

$$M = \Sigma_z (ABS (N_{MAX}))/n$$

where

N = departure of variable at some level.

Z = is summed over levels (ie 1000-200)

var = single variable (height, temperature, moisture, u-wind or v-wind)

Max can be over a specific domain or point. It can also be a large negative departure!

MTOTAL

the sum of all M's

$$\mathbf{MTOTAL} = (\mathbf{M}_{temp} + \mathbf{M}_{hgt} + \mathbf{M}_q \mathbf{M}_{wind}) / 4$$

where

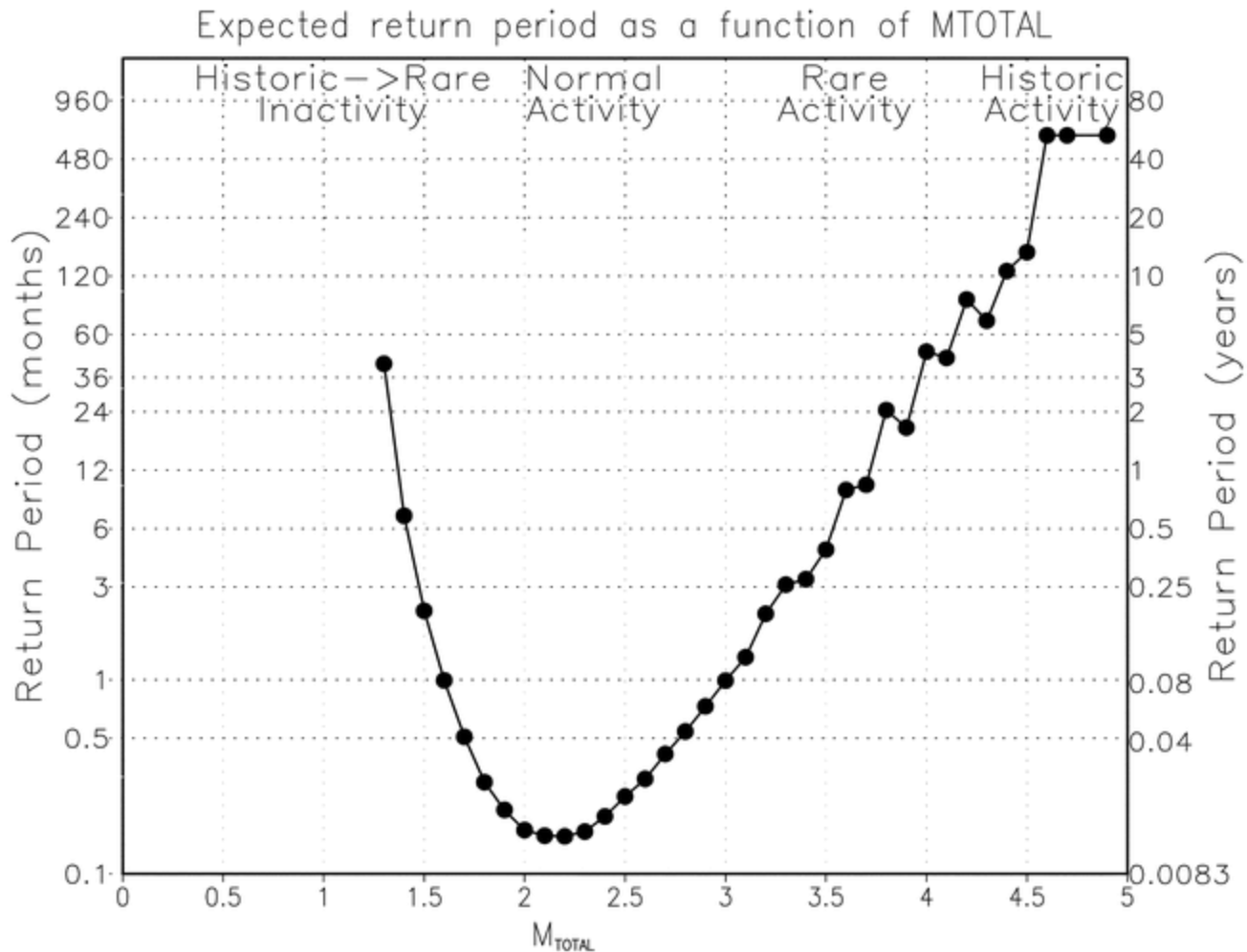
levels = 1000 to 200 hPa

M = Absolute value each Maximum N

4 for the four equally weighted variables in this example.

Return Periods

MTOTAL only (average of the integrated sum of u,v,T,q anomalies)



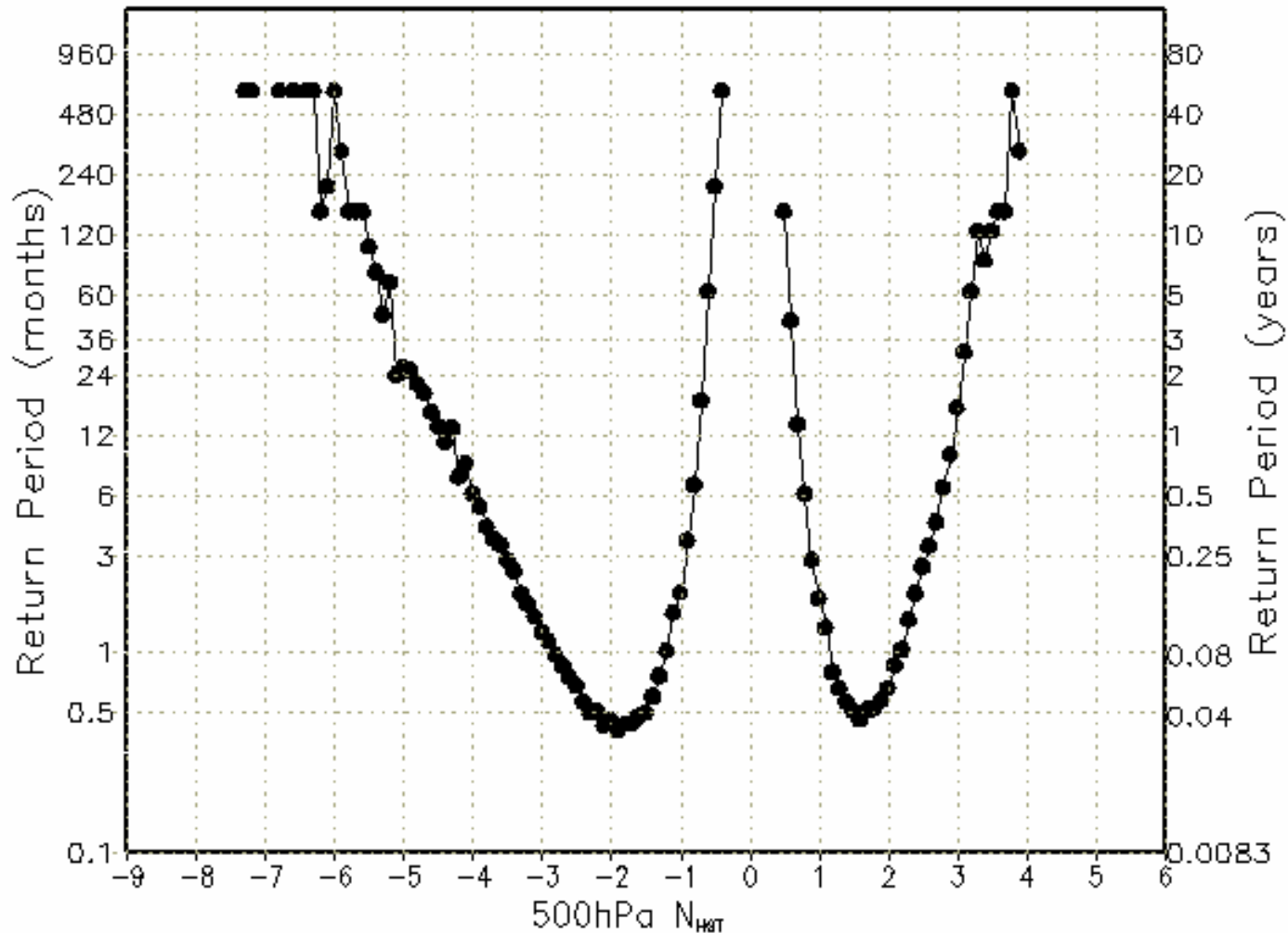
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Variable Return Periods

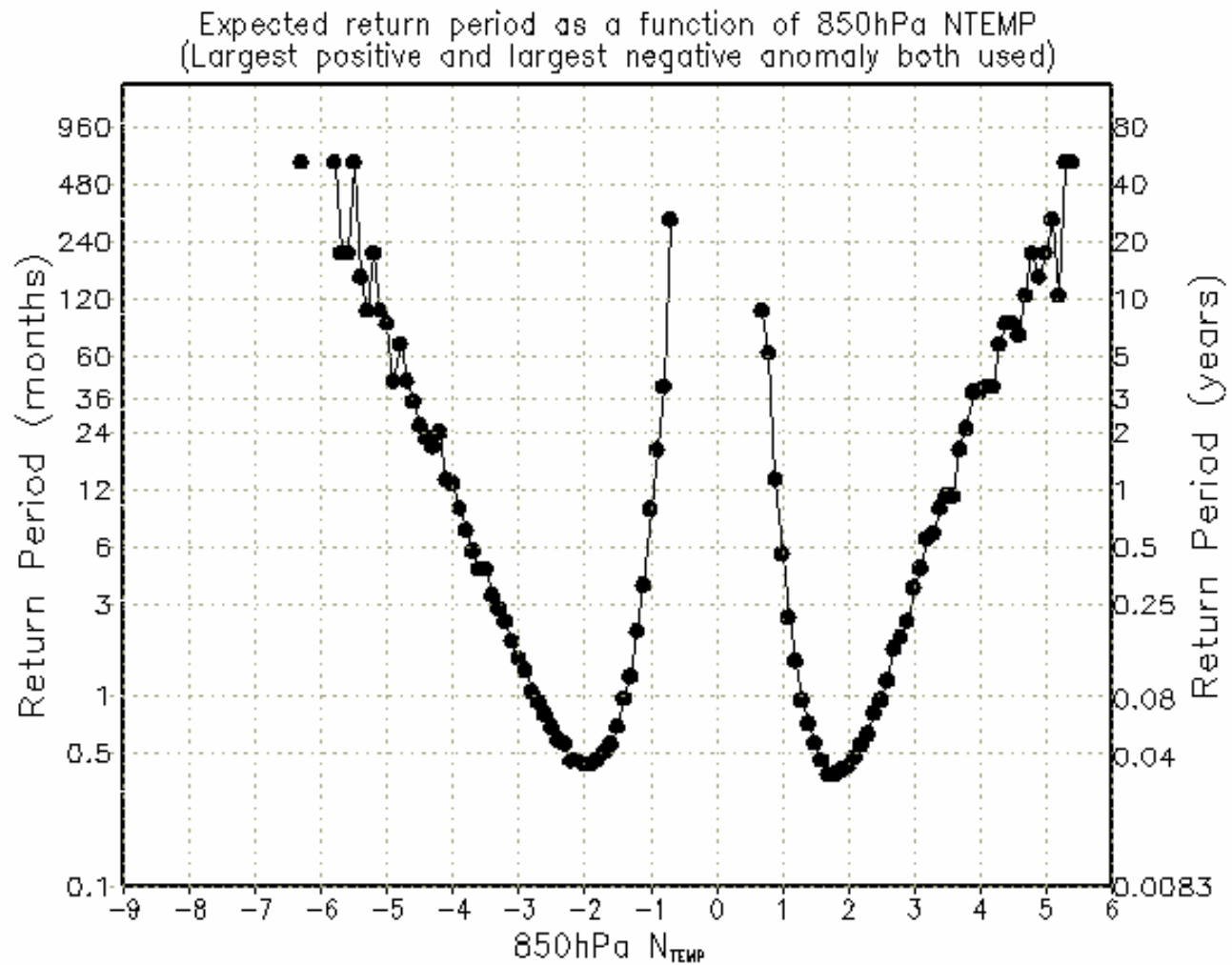
500 hPa heights

Expected return period as a function of 500hPa NHGT
(Largest positive and largest negative anomaly both used)



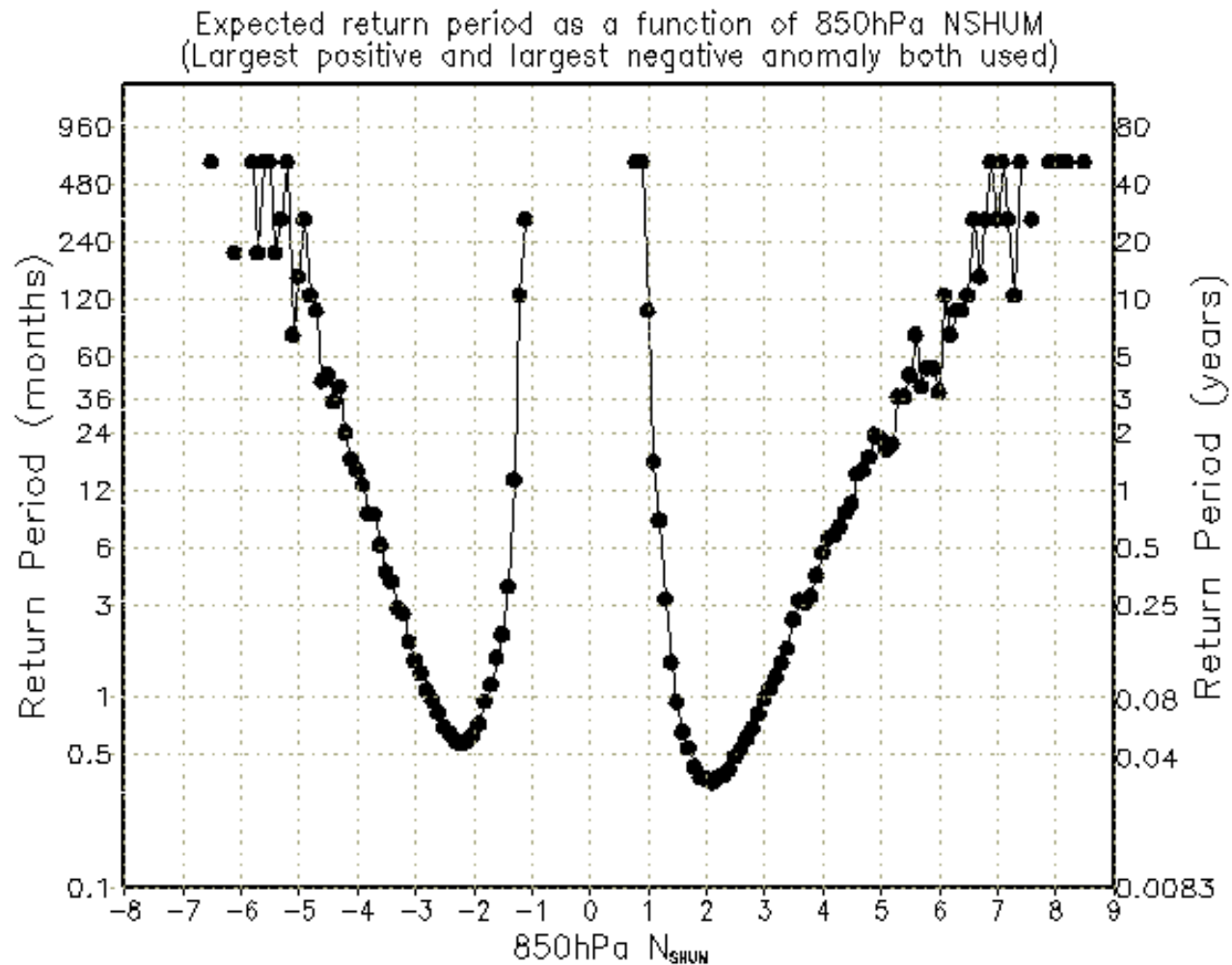
Variable Return Periods

850 hPa temperatures



Moisture returns

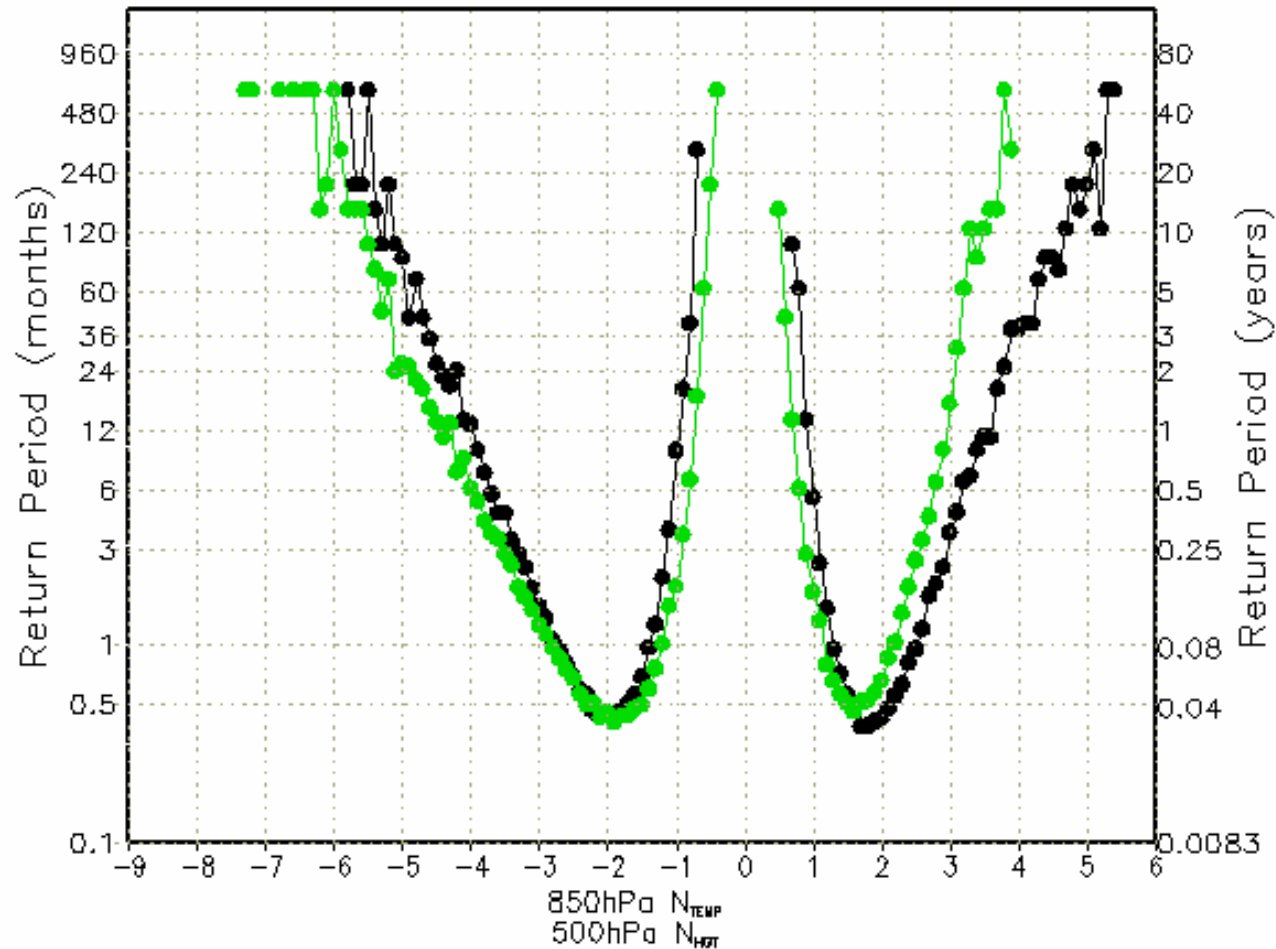
850 specific humidity



Variable Return Periods

850 hPa temperatures and 500 hPa heights

Expected return period as a function of 850 hPa NTEMP and 500 hPa NHGT
(Largest positive and largest negative anomaly both used)

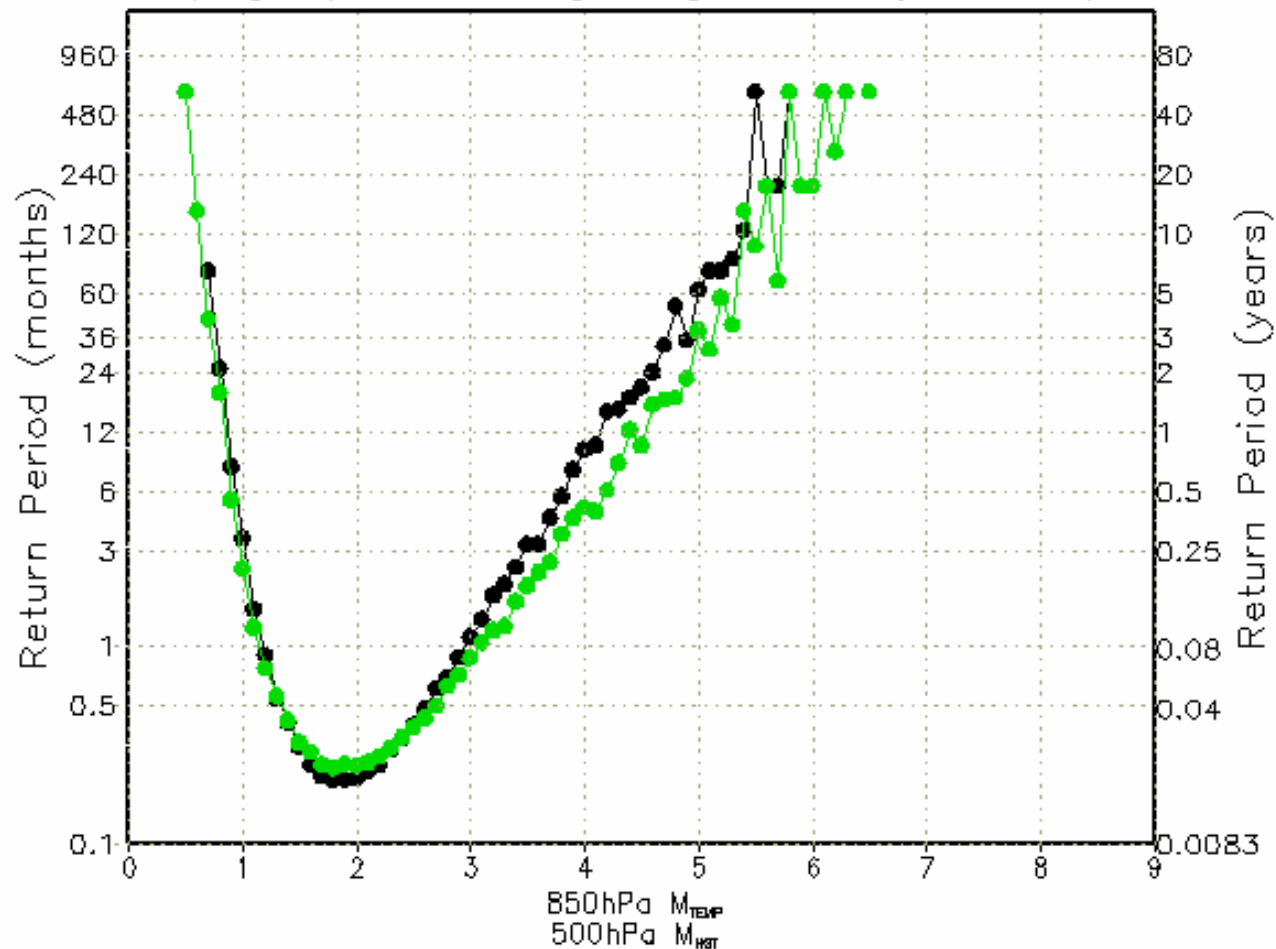


8 August,

Variable Return Periods

M by variable

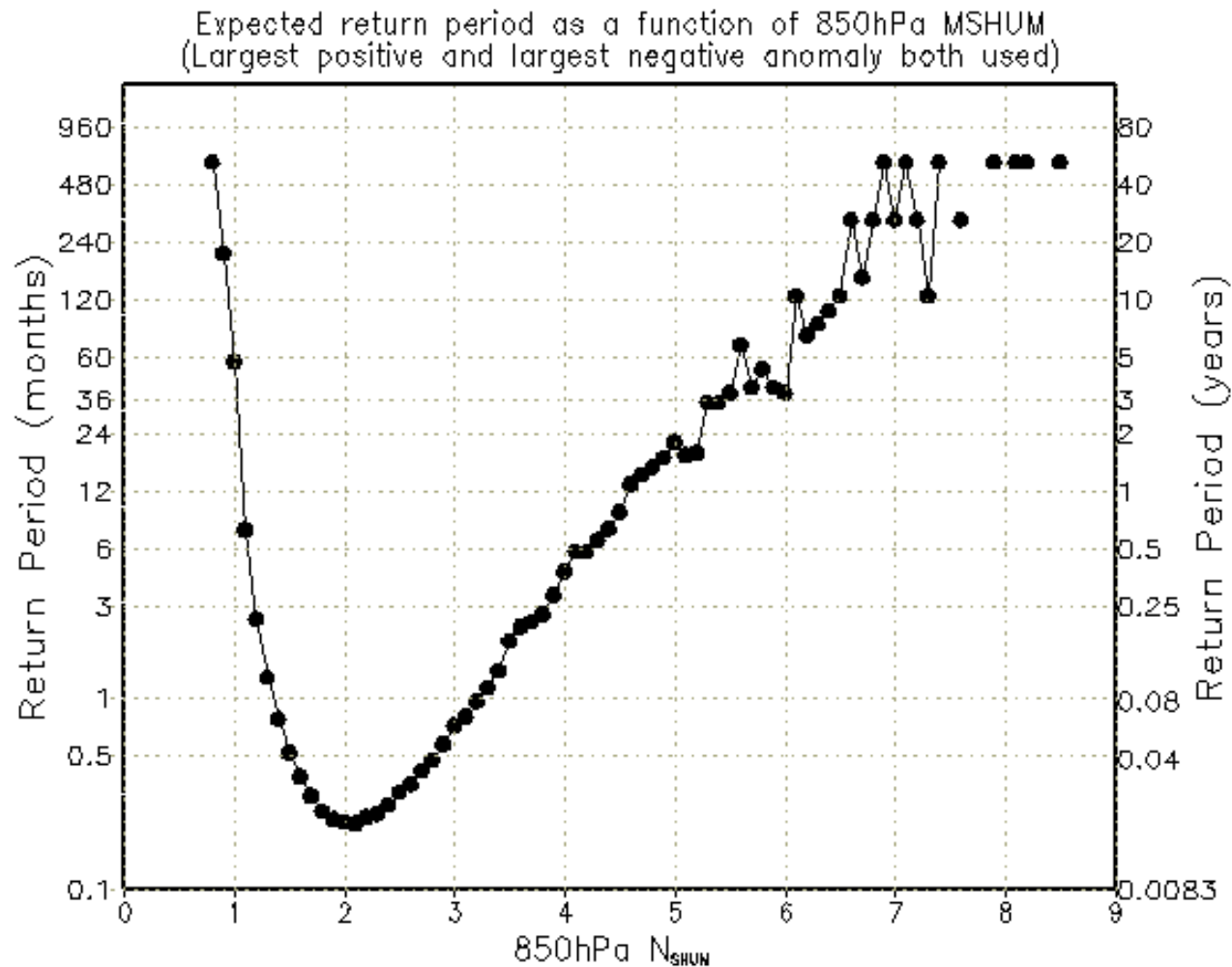
Expected return period as a function of 850 hPa MTEMP and 500 hPa MHGT
(Largest positive and largest negative anomaly both used)



8 August,

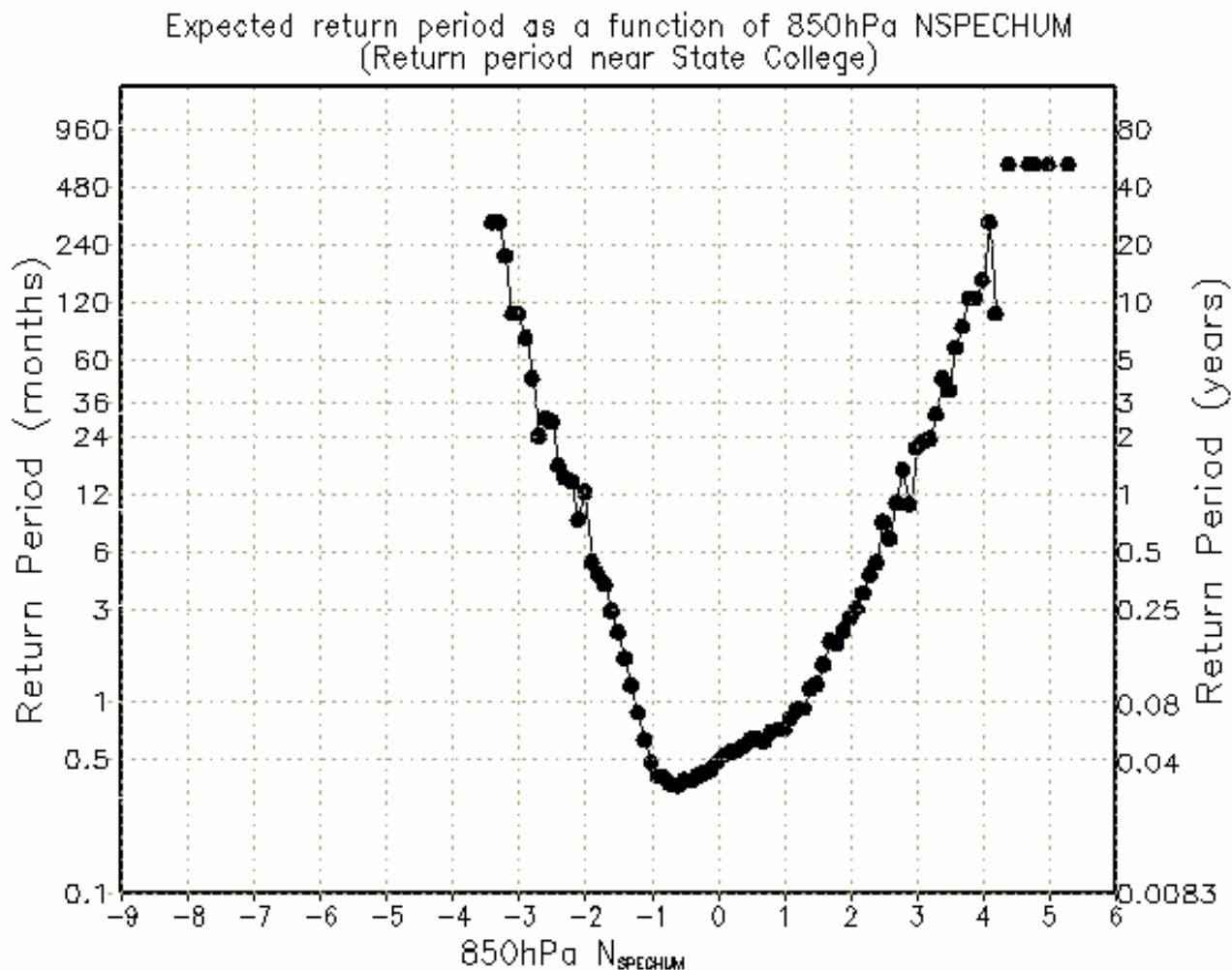
Moisture returns

850 specific humidity



Moisture returns at a Point

850 specific humidity near State College



8 August

Winter Storm Event Types

- The biggest events over eastern North America
 - *<http://eyewall.met.psu.edu/rankings/>*
- Snow storms
- Some recent events of note
 - *NWA Article June 2001: Nov 1992 Storm*
 - *The big blow 9-10 March 2002*
- Other

Record Eastern US Events 25N-50N/95W-65W

- **Hart and Grumm MWR Sept 2001**
- **Events:**
 - determined strictly by anomalies and no human interventions
 - *hurricanes were eliminated for data resolution reasons*
 - stratified by top of all time, by variables, and by Month
 - searched for studies on big events in WAF/MWR/NWA-Digest/QJRMS/Weather/Weatherwise/StormData
- **Events on line:**
 - <http://eyewall.met.psu.edu/rankings/>
- **Updated monthly, as necessary**

Top 20 Events

note many were worthy of research

Rank	Date	M_{TOTAL}	Event type and description	Event references
1	0000 UTC 9 Jan 1956	4.950	The Great Atlantic Low	Ludlum (1956)
2	1200 UTC 15 Jan 1995	4.723	Deep Gulf of Mexico storm	
3	0000 UTC 14 Mar 1993	4.577	Superstorm of 1993	Kocin et al. (1995); Dickinson et al. (1997)
4	1200 UTC 11 Jan 1975	4.567	Severe Minnesota Blizzard	
5	1200 UTC 8 Jan 1998	4.536	NE U.S./SE Canada icestorm	J. Gyakum and P. Sisson (1999, personal communication); DeGaetano (2000)
6	1200 UTC 28 Dec 1980	4.470	Deep Carolina coastal low	
7	1200 UTC 17 Mar 1983	4.464	Low-latitude intense cyclone	Dickinson et al. (1997)
8	0000 UTC 26 Nov 1953	4.396	Deep E U.S. storm	
9	0000 UTC 16 Oct 1954	4.392	Extratropical storm Hazel	Knox (1955); Palmén (1958)
10	1200 UTC 8 Jan 1958	4.356	Intense coastal storm	Ludlum (1958a)
11	1200 UTC 19 Jan 1977	4.341	Historic Florida freeze	Schwartz (1977)
12	1200 UTC 19 Jan 1996	4.308	NE U.S. flooding/snowmelt	Leathers et al. (1998)
13	0000 UTC 10 Jan 1978	4.261	Deep NE U.S. storm	
14	1200 UTC 31 Oct 1993	4.232	E U.S. elevation blizzard	Grumm and Nicosia (1997)
15	0000 UTC 4 Feb 1970	4.202	Eastern U.S. storm	
16	1200 UTC 22 Dec 1972	4.199	Deep Gulf of Mexico storm	
17	1200 UTC 11 Dec 1950	4.192	Intense offshore coastal storm	
18	1200 UTC 26 Jan 1978	4.179	The Cleveland superbomb	Gaza and Bosart (1990); Hakim et al. (1995), (1996)
19	0000 UTC 20 Oct 1989	4.179	SE U.S. record cold and snow	
20	1200 UTC 22 Jan 1959	4.176	Severe E U.S. snow/icestorm	Treidl (1959)

From: Hart and Grumm MWR Sept 2001

M_{TEMP}

Rank	Date	M_{TEMP}	Event type and description	Event references
1	0000 UTC 20 Oct 1989	5.355	SE U.S. record cold and snow	Schwartz (1977)
2	1200 UTC 19 Jan 1977	5.020	Historical Florida freeze	
3	1200 UTC 26 Nov 1953	4.959	Heavy central Appalachian snowstorm	
4	1200 UTC 7 May 1992	4.880		
5	1200 UTC 2 Nov 1966	4.835		
6	0000 UTC 2 Dec 1999	4.830		
7	0000 UTC 10 Sep 1998	4.816		
8	1200 UTC 18 Sep 1981	4.716		
9	1200 UTC 4 Aug 1956	4.683		
10	1200 UTC 28 Apr 1992	4.620		

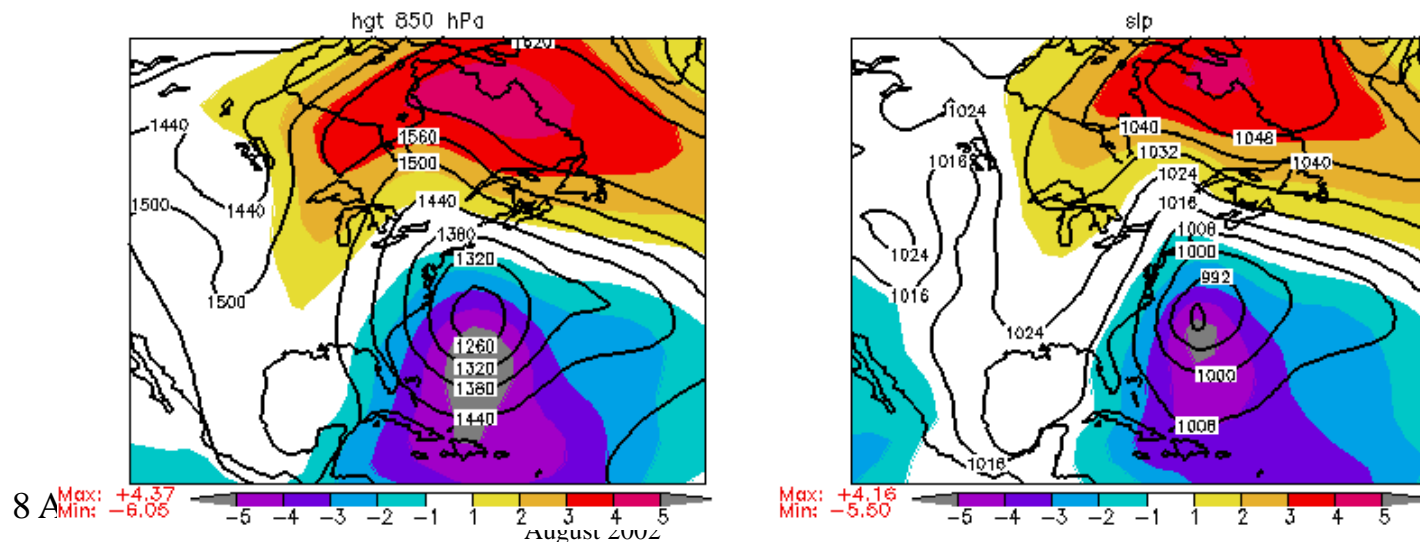
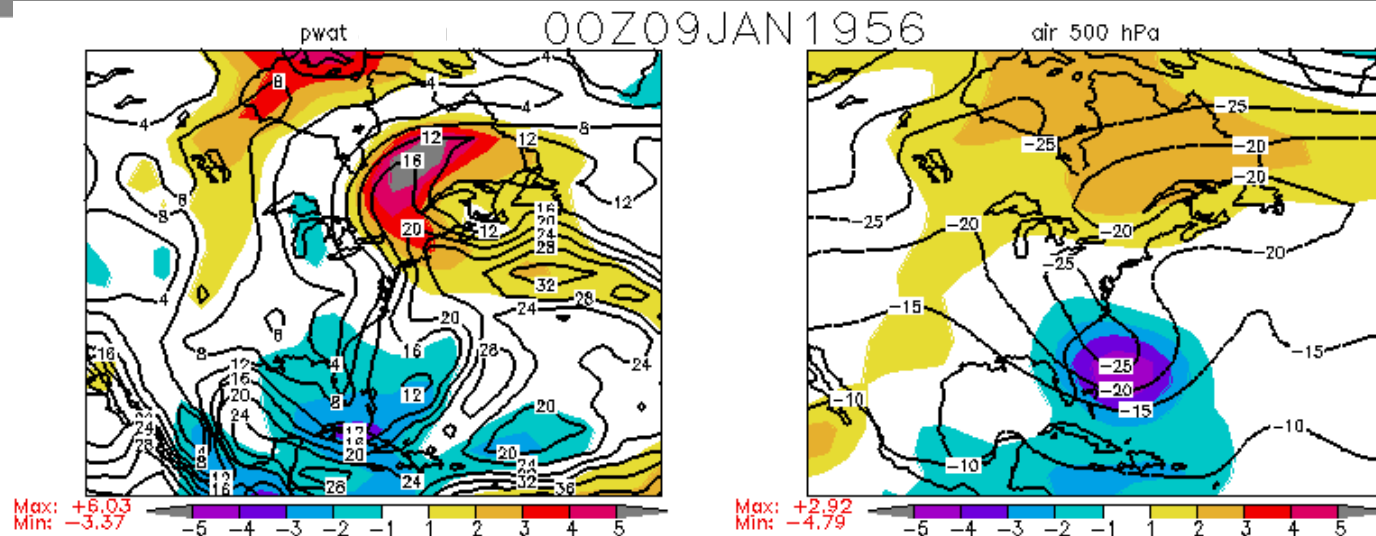
M_{HEIGHT}

Rank	Date	M_{HEIGHT}	Event type/description	Event references
1	1200 UTC 17 Mar 1983	6.847	Low-latitude intense cyclone	Dickinson et al. (1997)
2	0000 UTC 9 Jan 1956	6.120	The Great Atlantic Low	Ludlum (1956)
3	1200 UTC 19 Jan 1977	5.698	Historical Florida freeze	Schwartz (1977)
4	1200 UTC 11 Dec 1967	5.419	Deep Gulf of Mexico storm	Ludlum (1952) DiMego and Bosart (1982a,b); Bosart and Dean (1991)
5	0000 UTC 28 May 1973	5.404	Record Appalachian snowstorm	
6	0000 UTC 21 Nov 1952	5.358		
7	1200 UTC 23 Jun 1972	5.286	Extratropical storm Agnes	
8	0000 UTC 3 Feb 1998	5.252	Superstorm of 1993	
9	1200 UTC 13 Mar 1993	5.195		
10	1200 UTC 8 Jan 1958	5.193	Intense coastal storm	

M_{MOIST}

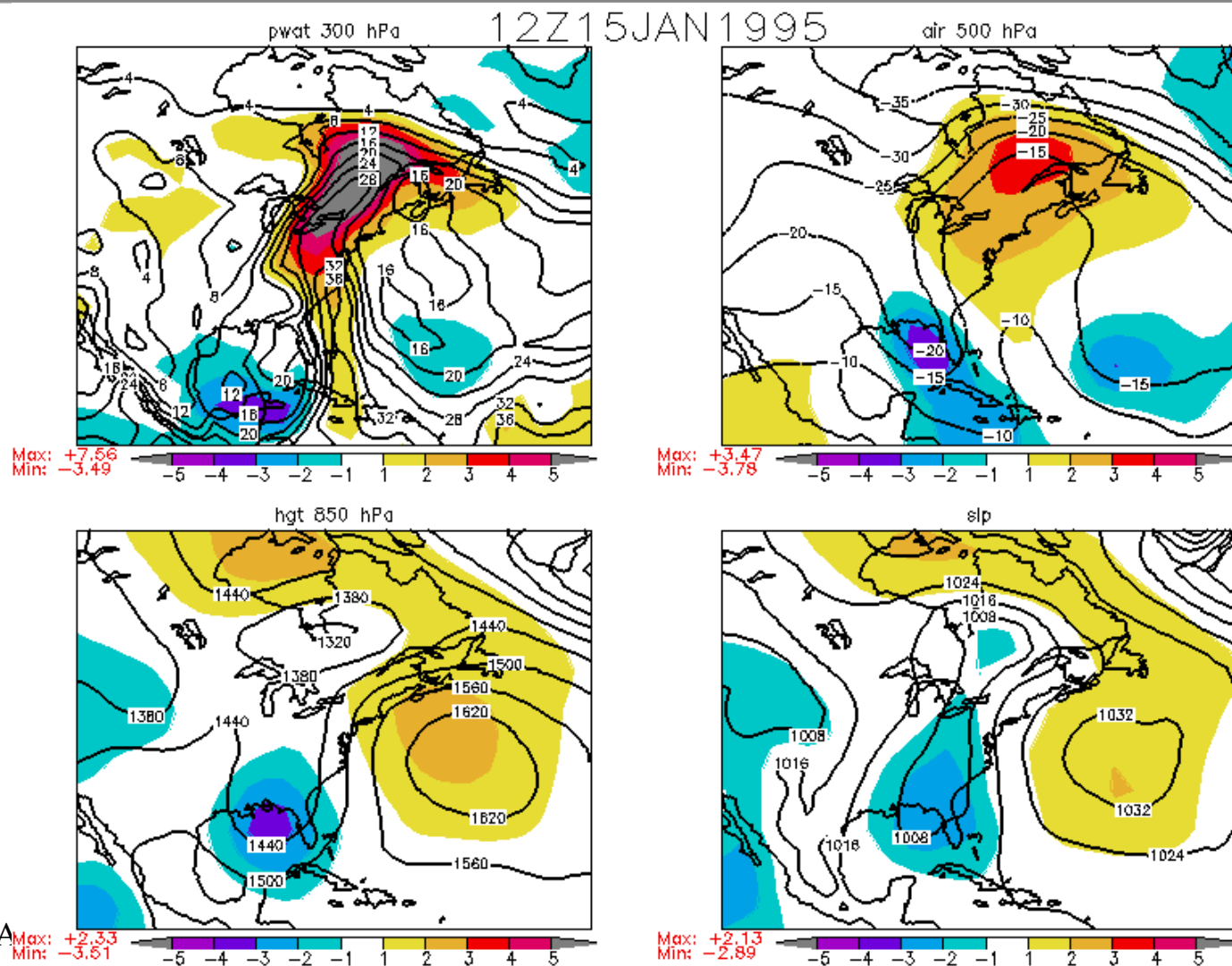
Rank	Date	M_{MOIST}	Event type and description	Event references
1	1200 UTC 15 Jan 1995	7.734	Deep Gulf of Mexico storm	Treidl (1959) J. Gyakum and P. Sisson (1999, personal communication); DeGaetano (2000) Leathers et al. (1998)
2	1200 UTC 22 Jan 1959	7.359	Severe E. U.S. snow-/icestorm	
3	1200 UTC 8 Jan 1998	7.104	NE U.S./SE Canada icestorm	
4	0000 UTC 20 Jan 1996	6.948	NE U.S. flooding/snowmelt	
5	1200 UTC 11 Jan 1975	6.767	Severe Minnesota blizzard	
6	1200 UTC 4 Jan 1950	6.654		
7	0000 UTC 10 Jan 1978	6.536		
8	1200 UTC 26 Jan 1950	6.461		
9	0000 UTC 24 Jan 1999	6.454		
10	0000 UTC 5 Jan 1997	6.285		

The singular event 0000 UTC 9 Jan 1956



#2

1200 UTC 15 Jan 1995

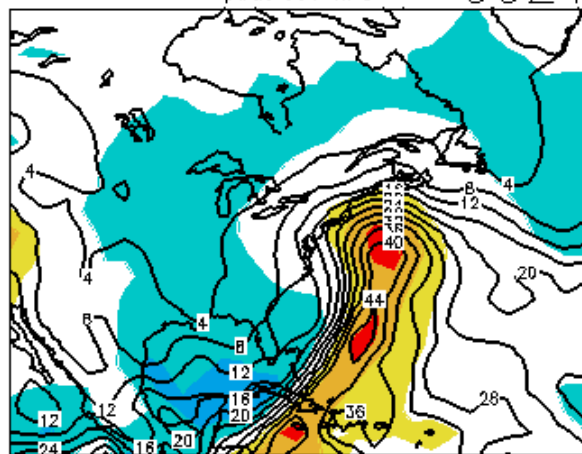


#3

The Storm of the Century

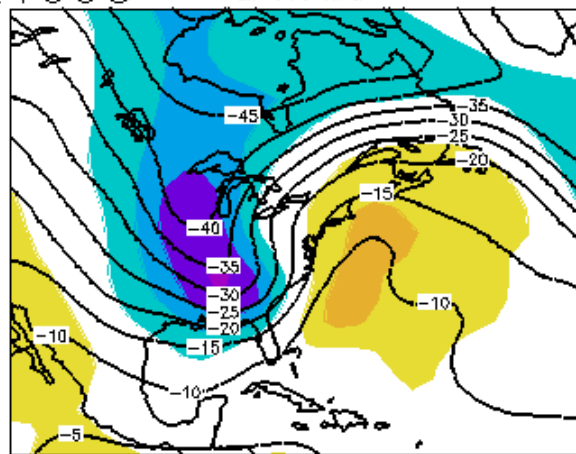
00Z 14 MAR 1993

pwat 300 hPa



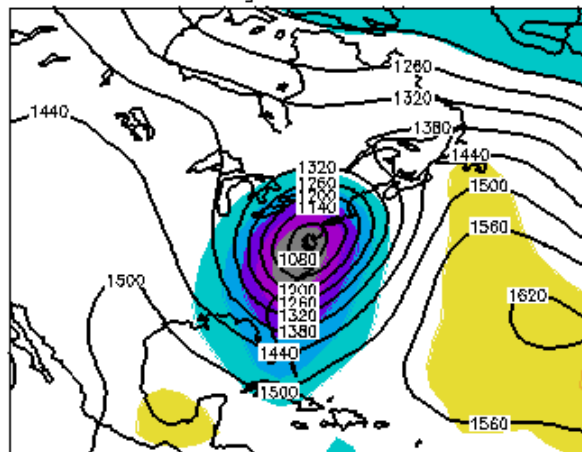
Max: +3.57
Min: -2.57

air 500 hPa



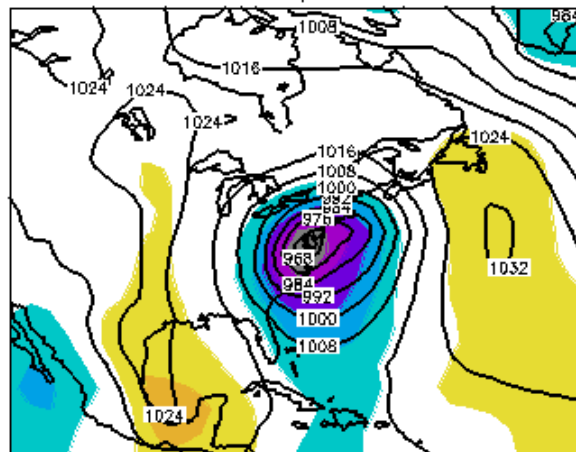
Max: +2.44
Min: -4.14

hgt 850 hPa



Max: +2.05
Min: -6.12

slp



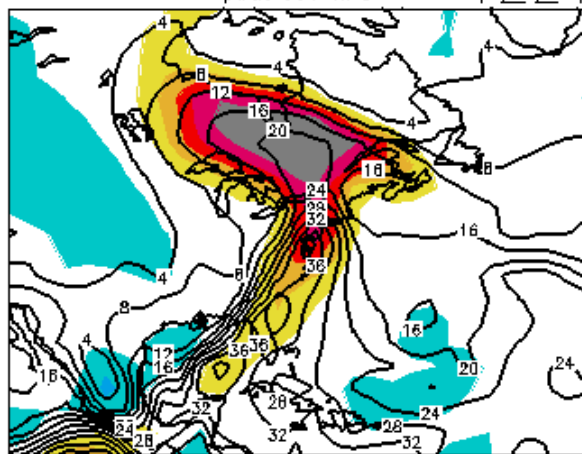
Max: +2.48
Min: -6.26

#4

Minnesota Blizzard

12Z 11 JAN 1975

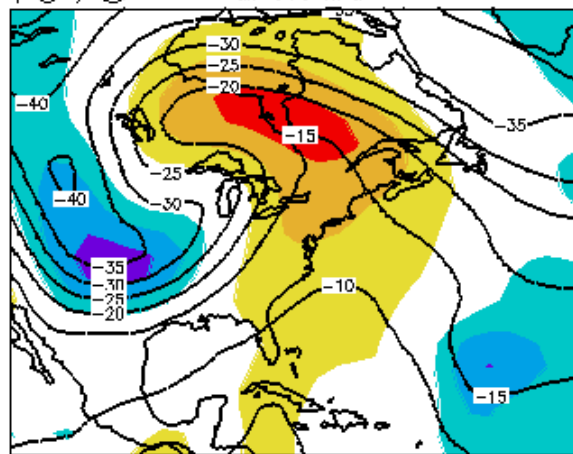
pwat 300 hPa



Max: +6.44
Min: -2.36

-6 -4 -3 -2 -1 1 2 3 4 5

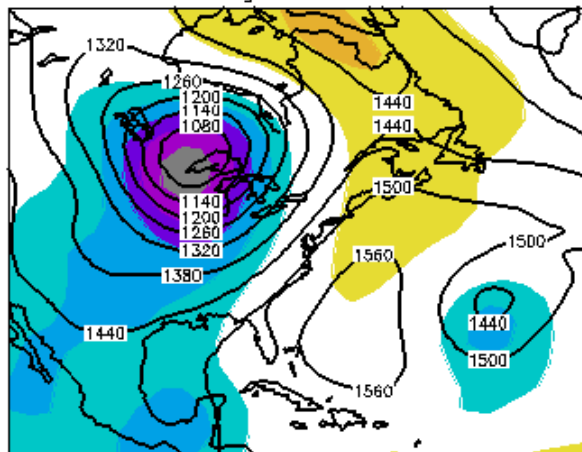
air 500 hPa



Max: +3.45
Min: -3.44

-6 -4 -3 -2 -1 1 2 3 4 5

hgt 850 hPa

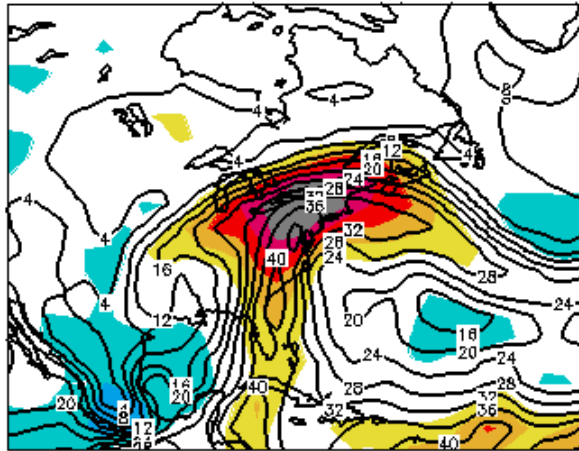


#5

Major Northeast Icestorm

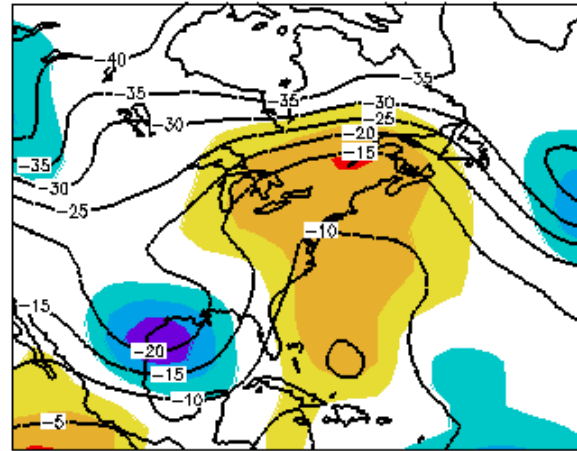
12Z08JAN1998

pwat 300 hPa



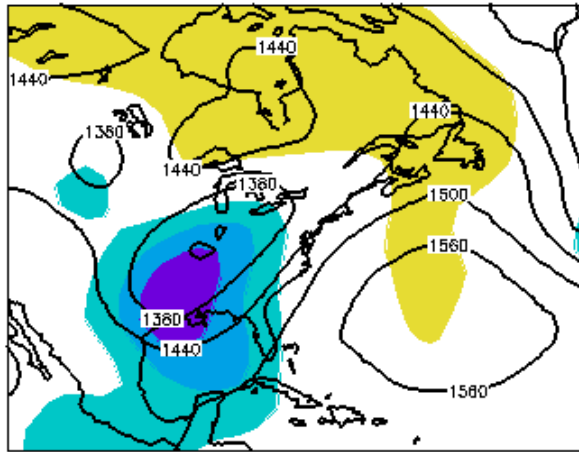
Max: +6.24
Min: -3.06

air 500 hPa



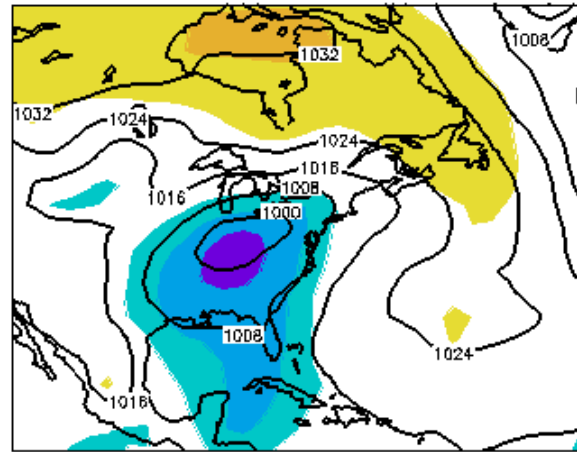
Max: +3.09
Min: -3.64

hgt 850 hPa



Max: +1.85
Min: -3.93

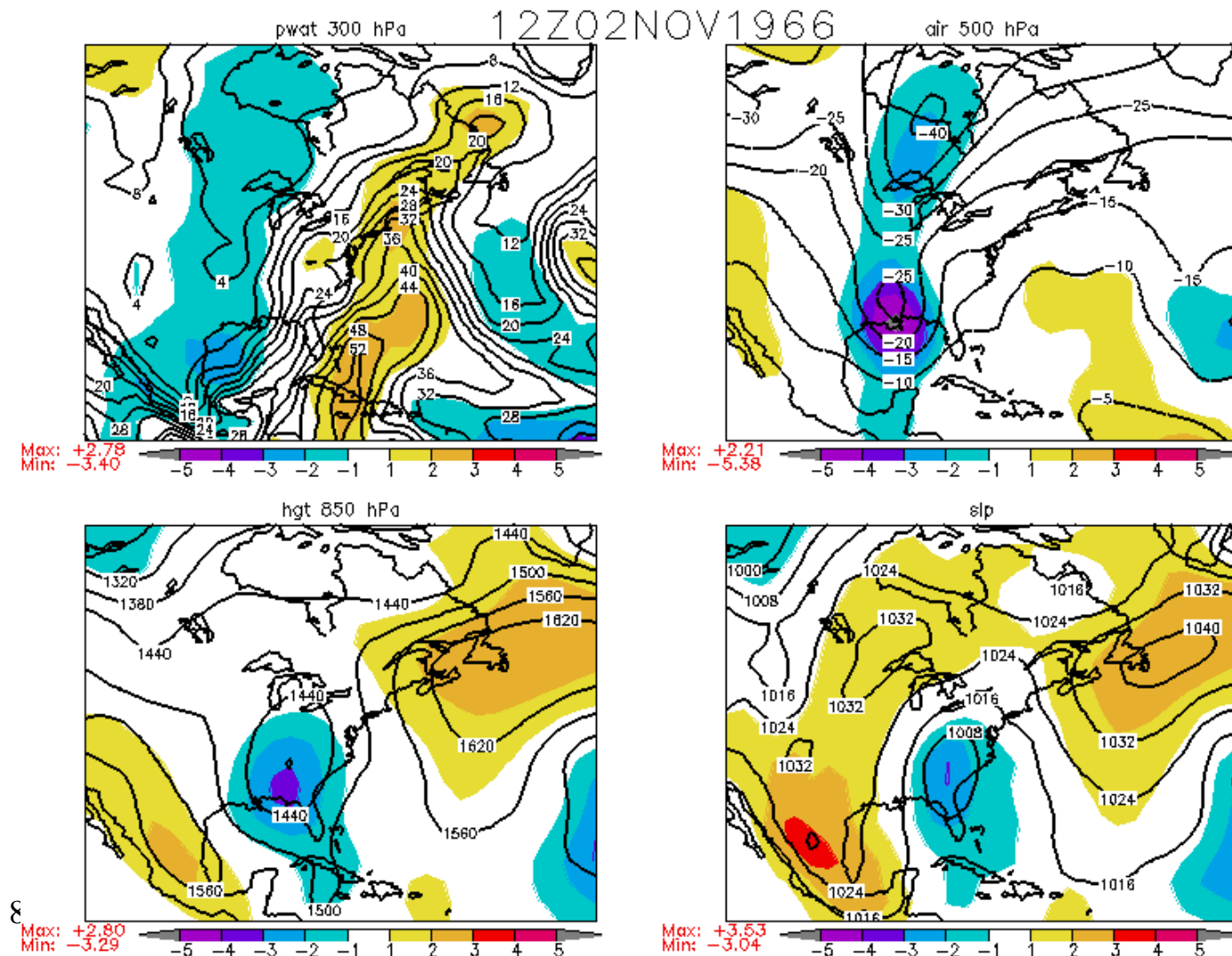
slp



Max: +2.16
Min: -3.46

#2 November Event

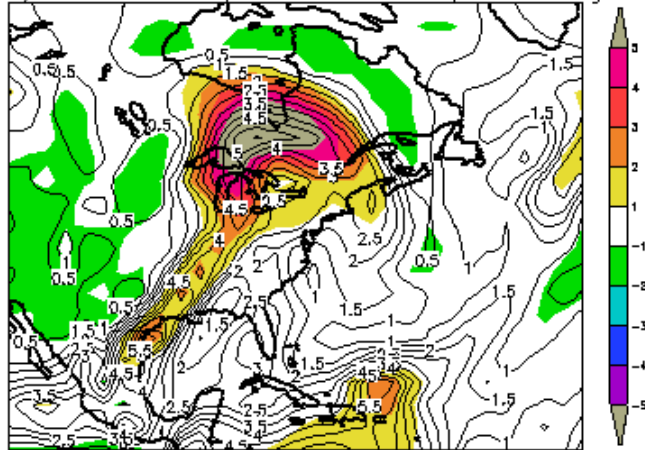
Appalachian Snow storm



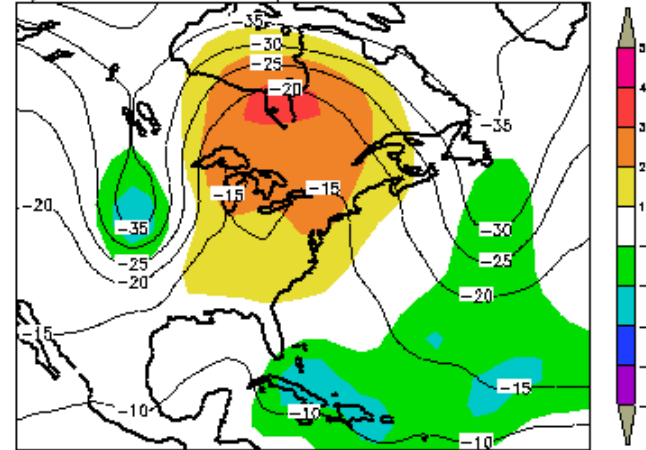
#3 February Event

Record mid-winter Warmth

a) 700 hPa Specific Humidity Anomaly

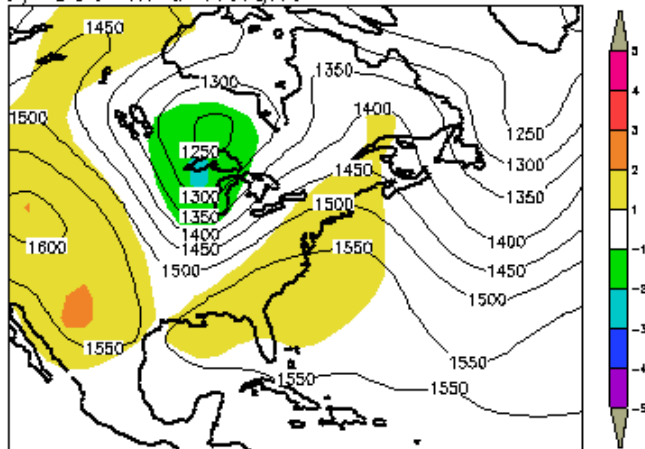


b) 500 hPa Temperature

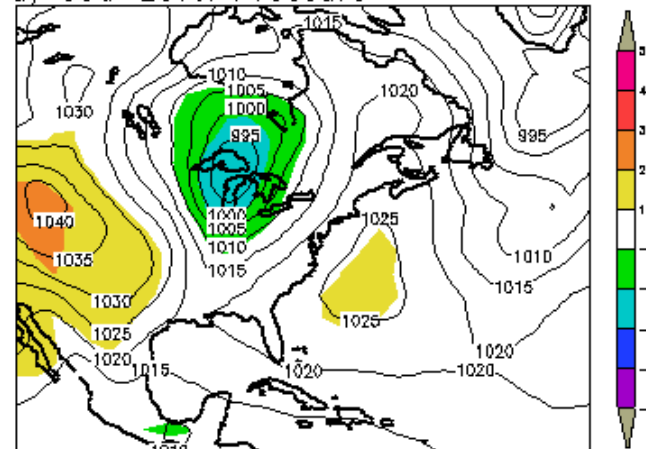


00Z12FEB1999

c) 850 hPa Height



d) Sea-Level Pressure



Historic Heavy Event Types

- **Snow storms**
- **Thermal events**
 - *Arctic outbreaks*
 - *record heat events*
- **Severe weather events**
 - *tornadic event signatures*
 - *derecho signatures*
- **flood events**
 - *cut-off lows*
 - *east-west fronts*
 - *sharp cold fronts (Narrow cold frontal rainbands)*

Applications

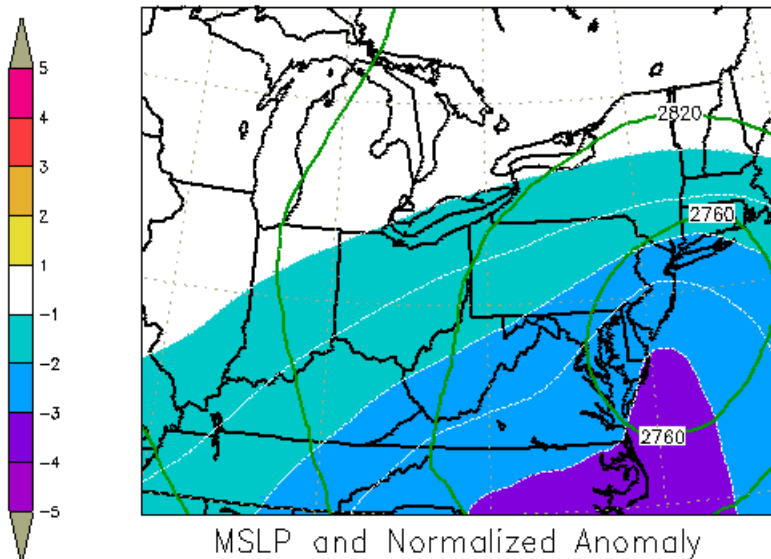
- **Know the Climatology of event types**
 - *signatures of associated anomalies*
 - *patterns of associated anomalies*
- **Apply this to model data**
 - select model fields relative to departures
 - allows one to see when models are forecasting
 - *big snow storms*
 - *big rain storms*
 - *heat waves*
 - models show great skill in this with some caveats

Heavy snow Model Application

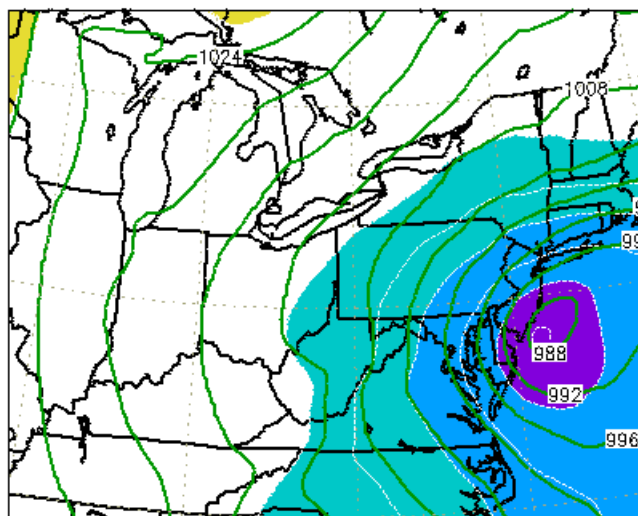
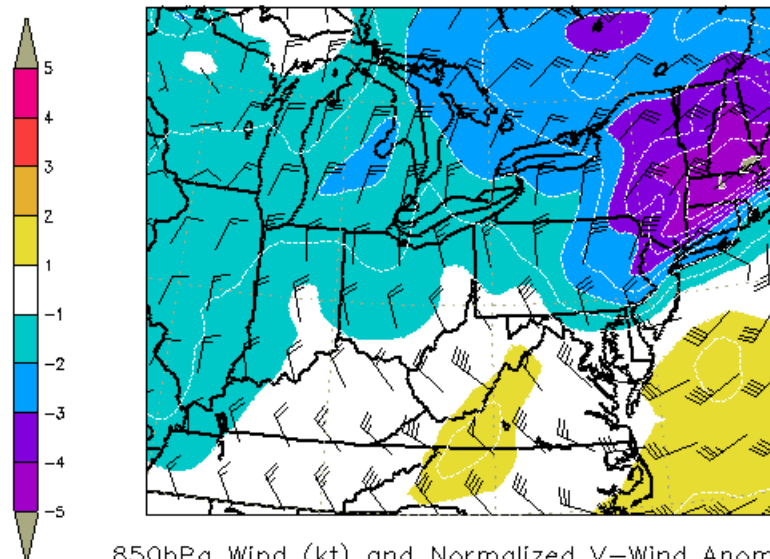
we are talking winter here!

- **30 December East Coast snow storm**
 - *NYC biggest December snow in 40 years*
 - ***applying Climatological Fields to model forecasts!***
- **Model forecast a significant/record event**
 - *Eta did have a track and depth error*
 - *but signal of a big storm was clearly evident*
- **Signals:**
 - *anomalous low (height and mslp)*
 - *anomalous easterlies*
 - *warm surge in warm sector*

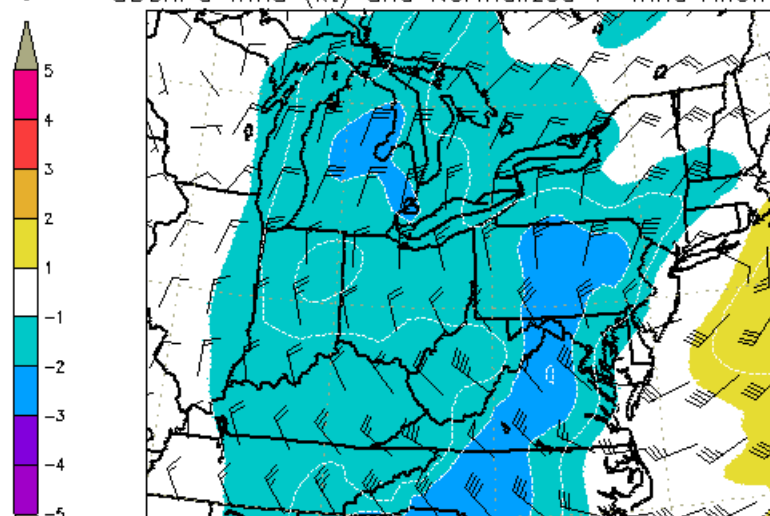
00Z29DEC2000 Eta 48hr Forecast Valid 00Z31DEC2000
700hPa Height and Normalized Anomaly



06Z29DEC2000 Eta 48hr Forecast Valid 06Z31DEC2000
850hPa Wind (kt) and Normalized U-Wind Anomaly



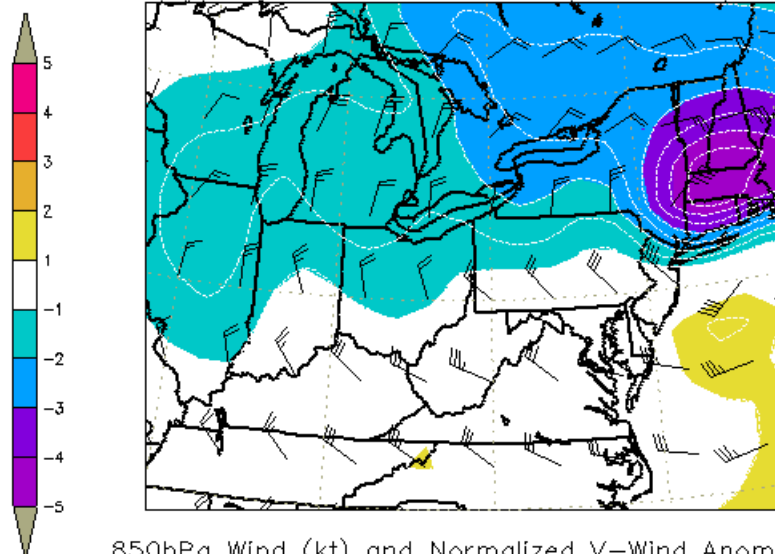
LEGEND:
Forecasts=Green Contour
Departure from 31DEC normal (# Std Dev)=Shading, White Contour
August 2002



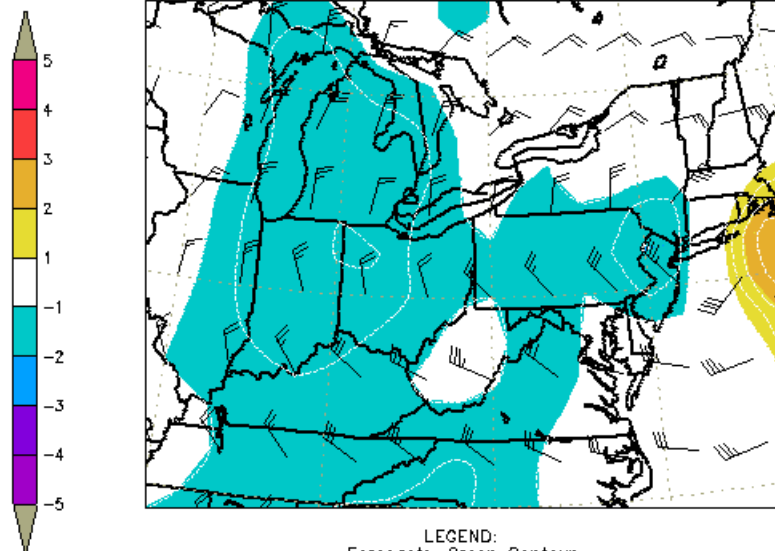
LEGEND:
Forecasts=Green Contour
Departure from 31DEC normal (# Std Dev)=Shading, White Contour

Twins? Steadfast AVN forecasts

12Z29DEC2000 AVN 36hr Forecast Valid 00Z31DEC2000
850hPa Wind (kt) and Normalized U-Wind Anomaly

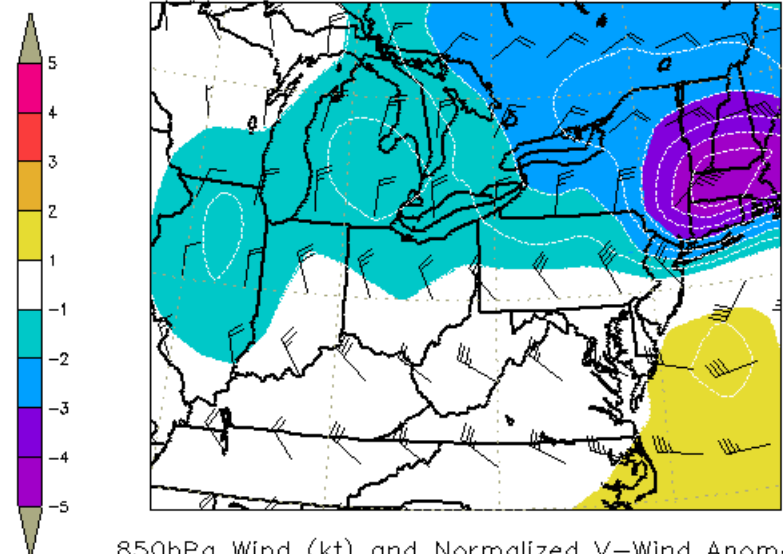


850hPa Wind (kt) and Normalized V-Wind Anomaly

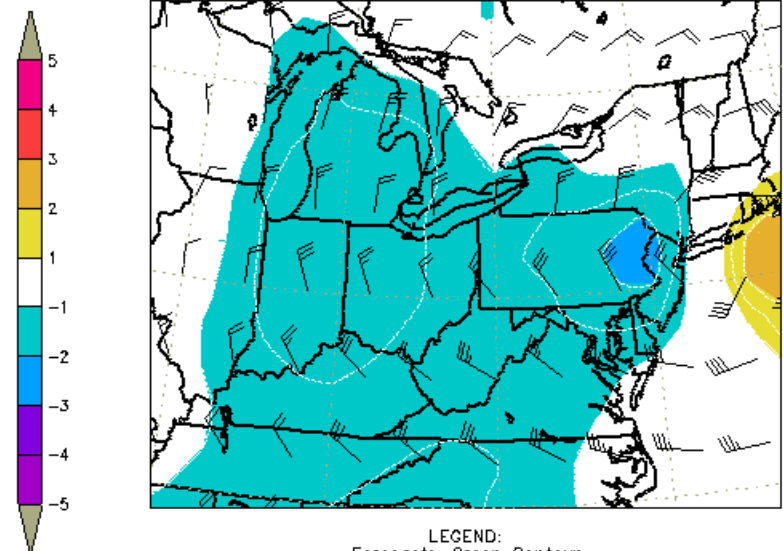


LEGEND:
Forecasts=Green Contour
Departure from 31DEC normal (# Std Dev)=Shading, White Contour

00Z29DEC2000 AVN 48hr Forecast Valid 00Z31DEC2000
850hPa Wind (kt) and Normalized U-Wind Anomaly



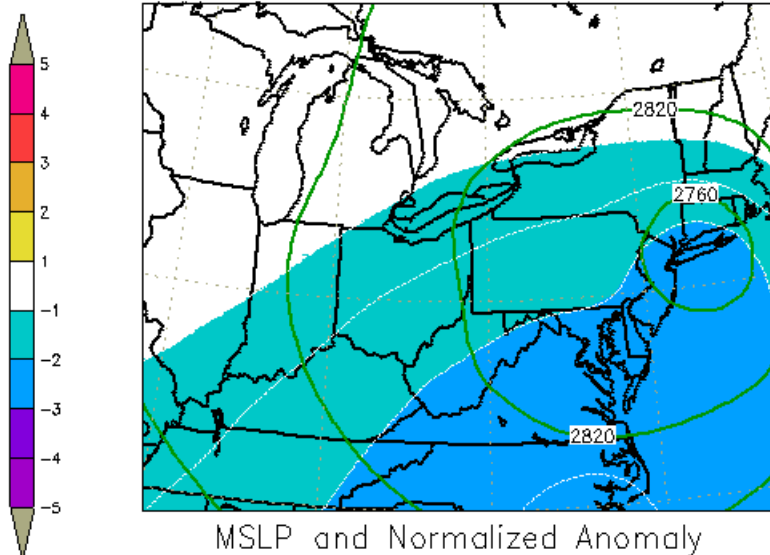
850hPa Wind (kt) and Normalized V-Wind Anomaly



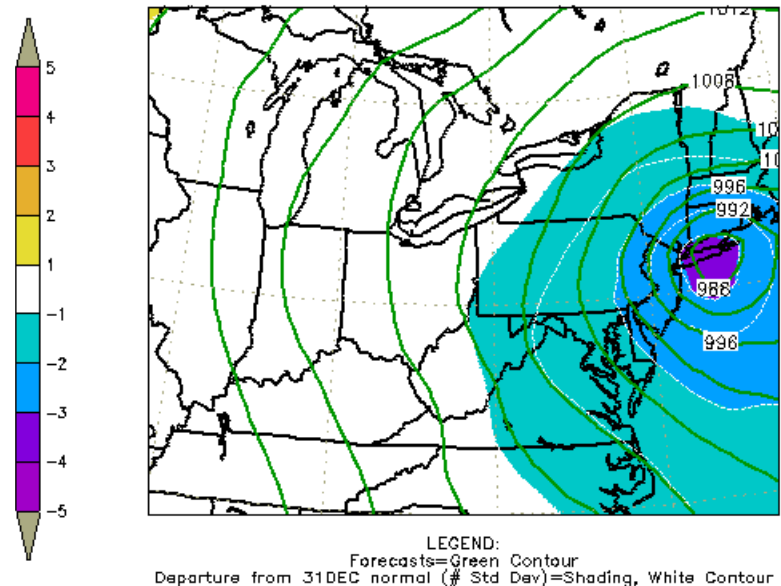
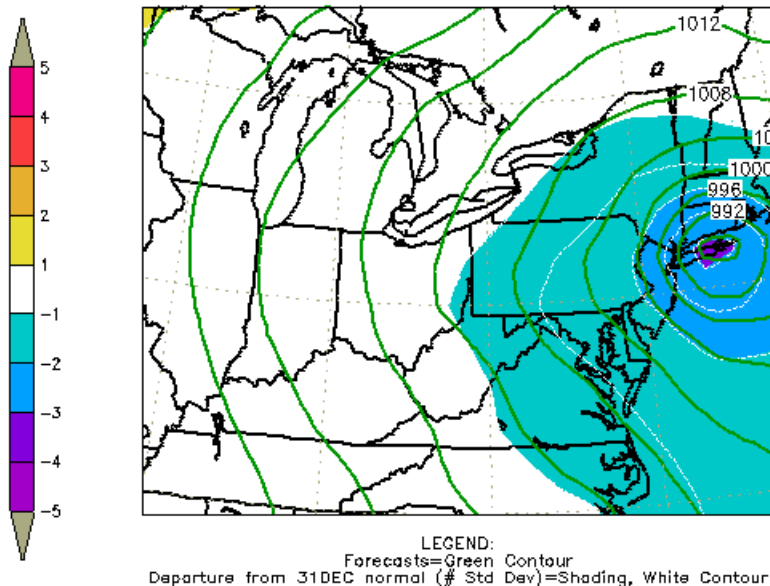
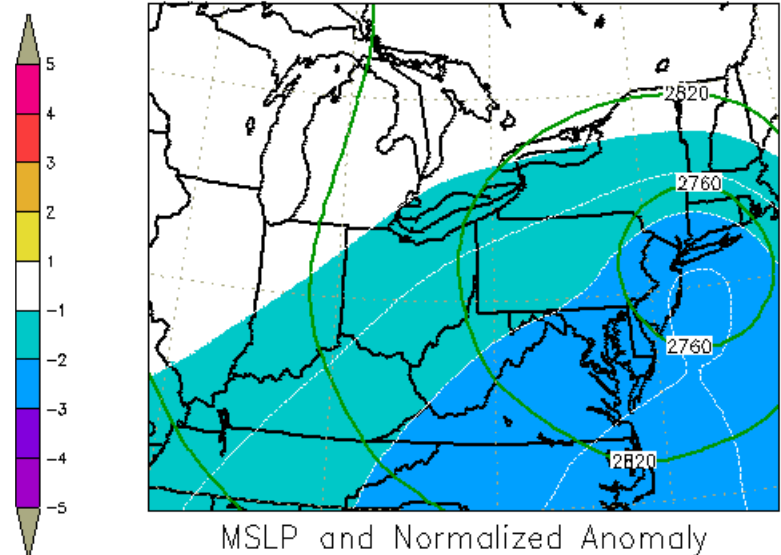
LEGEND:
Forecasts=Green Contour
Departure from 31DEC normal (# Std Dev)=Shading, White Contour

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12Z29DEC2000 AVN 36hr Forecast Valid 00Z31DEC2000
700hPa Height and Normalized Anomaly



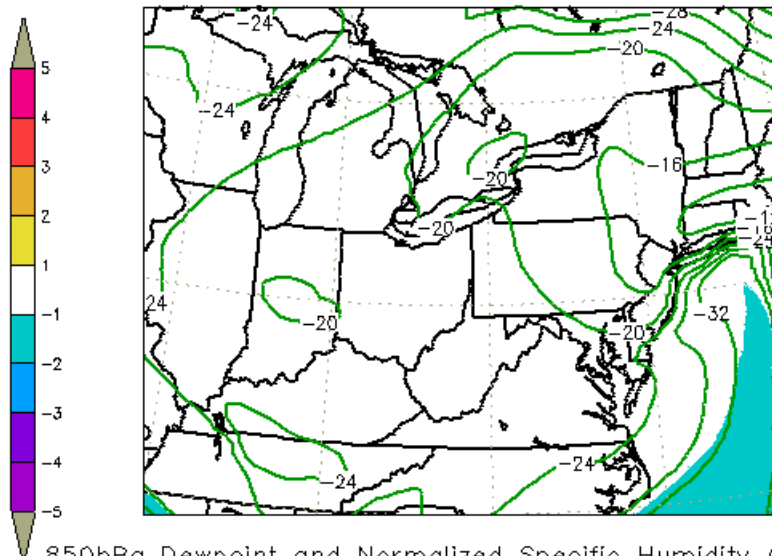
00Z29DEC2000 AVN 48hr Forecast Valid 00Z31DEC2000
700hPa Height and Normalized Anomaly



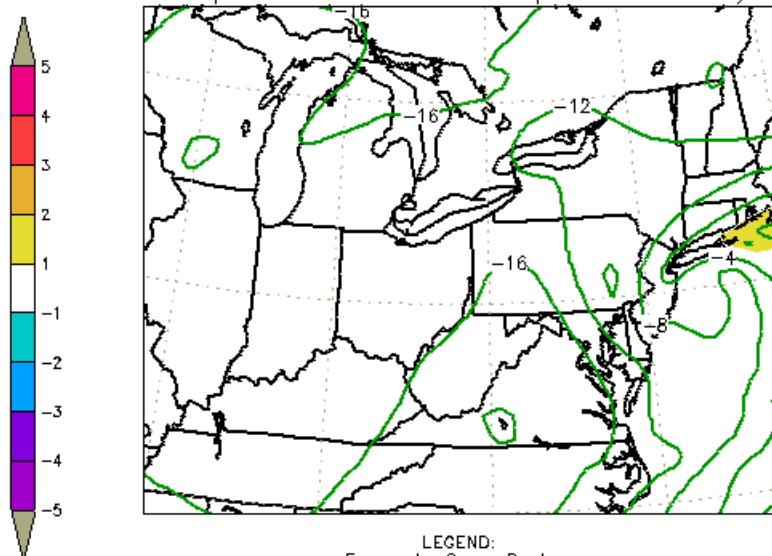
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00Z30DEC2000 Eta 21hr Forecast Valid 21Z30DEC2000
700hPa Dewpoint and Normalized Specific Humidity Anomaly

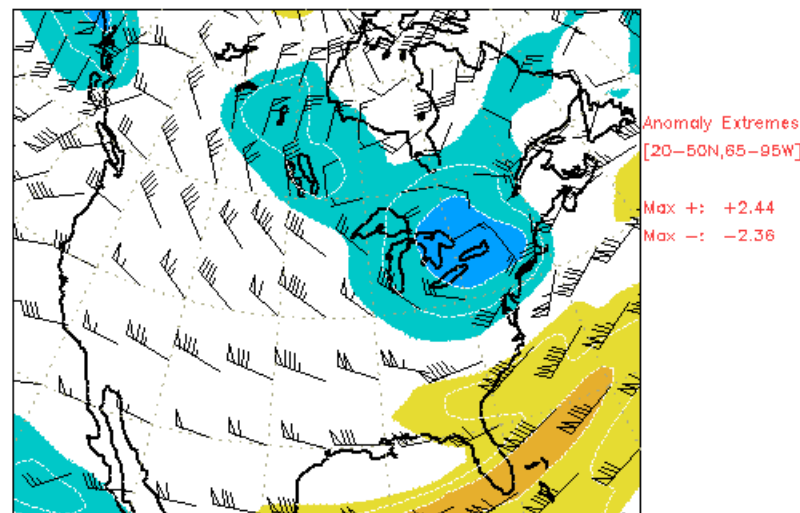


850hPa Dewpoint and Normalized Specific Humidity Anomaly

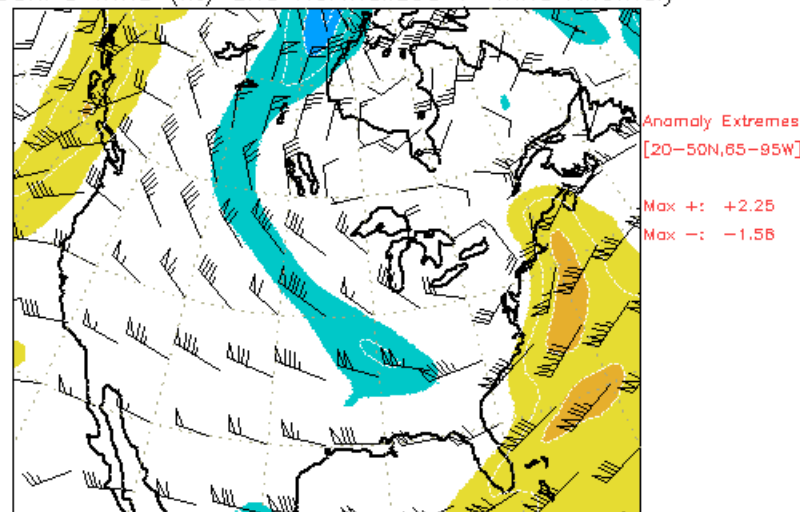


LEGEND:
Forecasts=Green Contour
Departure from 30DEC normal (# Std Dev)=Shading, White Contour

0Z29DEC2000 AVN 48hr Forecast Valid 00Z31DEC2000
250hPa Wind (kt) and Normalized U-Wind Anomaly



250hPa Wind (kt) and Normalized V-Wind Anomaly



LEGEND:
Forecasts=Green Contour
Departure from 31DEC normal (# Std Dev)=Shading, White Contour

30 December Snow case

- **Models showed**

- *showed sharp and strong easterly jet anomaly*
 - *these anomalies are often associated with significant QPF events see Preprint AMS-QPF Sym. Jan 2001.*
- *showed anomalous surface cyclone and upper level low*
- *suggested a potentially significant storm for the date.*

- **Comparison to Kocin and Uccellini Events**

- *Grumm and Hart 2001 WAF*

East Coast and Pennsylvania Snow Storms						
<i>Date</i>	<i>Source</i>	<i>500 hPa heights</i>	<i>700 hPa heights</i>	<i>850 hPa Temp</i>	<i>MSLP</i>	<i>Notes</i>
13 Jan 1964	KU	-4.1	-3.5	-4.1	-2.5	• <i>Anomalous ridge in Canada +3 MSLP</i>
25 Dec 1966	KU	-2.8	-2.9	-2.5	-2.9	• <i>Anomalous Ridge northern Canada</i>
30 Jan 1966	KU	-4.1	-4.1	-4.0	-3.3	• <i>Anomalous Ridge Canadian maritimes +3</i>
7 Feb 1967	KU	-0.5	-1.0	-	-2.5	•
26 Dec 1969	KU	-2.5	-2.5	-2.0	-2.5	• <i>Anomalous anticyclone Canadian maritimes +2</i>
09 Feb 1969	KU	-2.0	-2.5	-1.5	-3.5	• <i>Deep low</i>
18-24 Feb 1969	KU	-	-	-	-	• <i>Anomalous ridging at 500,700, and surface near Hudson Bay +3 STD</i>
20 Feb 1972	KU	-3.50	-3.2	-3.8	-3.3	• <i>Strong storm</i>
17 Dec 1973	A					• <i>Anomalous 500 mb ridge over N ATL</i> • <i>Anomalous negative tilted trough US</i> • <i>Anomalous surface low and high couplets</i>
20 Jan 1978	KU	-2.5	-2.5	-	-2.5	• <i>Deep strong southern stream wave at early stages</i> • <i>Large surface anticyclone over central North America</i>
26 Jan 1978	B	-2.75	-3.75	-2.50	-4.5	• <i>Cleveland Super bomb</i> • <i>Strong great lakes cyclone</i>
06 Feb 1978	KU	-2.5	-2.5	-2.5	-2.5	• <i>Anticyclone +3.5 Hudson Bay area</i>
06 Apr 1982	KU	-2.5	-2.5	-2.5	-4	• <i>Anticyclone +2</i> • <i>Deep surface low developed</i>
23 Jan 1987	KU	-3.4	-2.9	-3.4	-3.4	• <i>Rapidly Developing Cyclone</i>
27 Jan 1987	KU	-4.1	-2.7	-3.6	-2.1	• <i>Rapidly Developing Cyclone</i>
11 Feb 1983	KU	-0.5	-1.0	-	-2	• <i>Large Canadian anticyclone +3</i>
11 Nov 1987	A	-2.5	-2.5	-2.5	-2.5	• <i>Mesoscale shortwave</i>
16 Dec 1987	S	-2.50	-3.50	-2.50	-3.5	• <i>Midwest storm 1987</i>
10-11 Dec 1992	A	-3.25	-3.31	-2.33	-3.03	• <i>Anomalous 500 mb trough</i> • <i>Anomalous 500 mb ridge over eastern Canada</i>

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Snow storm findings

- **East Coast and Midwest**

- distinct signatures of features
 - *study in Michigan*
 - *study in State College and Mid-Atlantic with Wakefield*
- Some key features:
 - *anomalous 850 hPa jet*
 - *anomalous surface, 850, 700, and 500 cyclone*
 - *thermal anomalies*

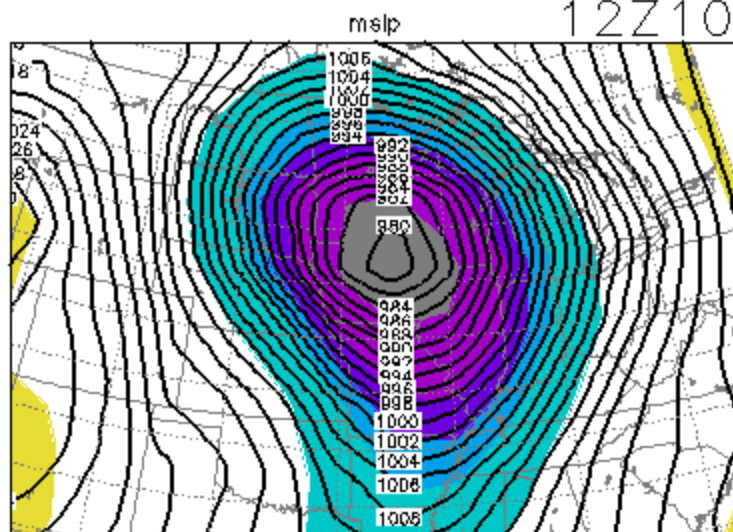
- **Kocin and Uccellini**

- there storms typically were in the MTOTAL 2 range
- the super storm was an exceptional event

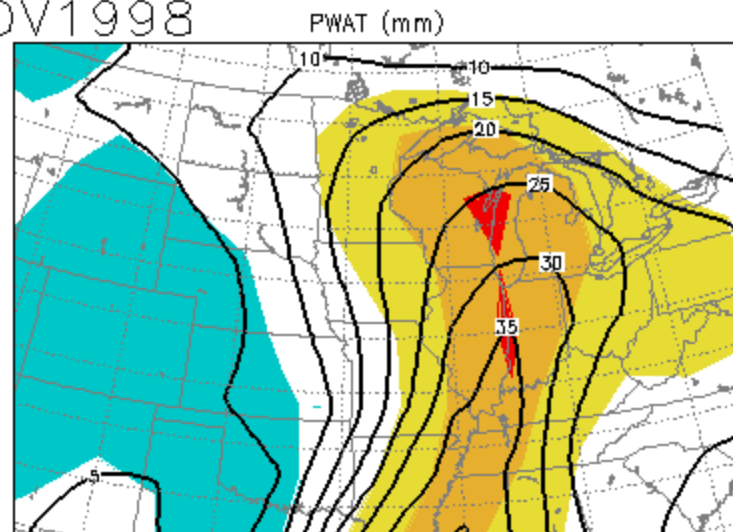
Winter Wind Events

- **10 November 1998 record storm**
 - *\$40 million in damage IL,IA,KY,MI,MN and WI*
 - *large are winds ≥ 50 kts*
 - *not a top-ten November event!*
 - *But had a signal*
- **9 March 2002**
 - the big blow
 - winter storm with strong winds
 - killed people in Chicago on Saturday 9 March

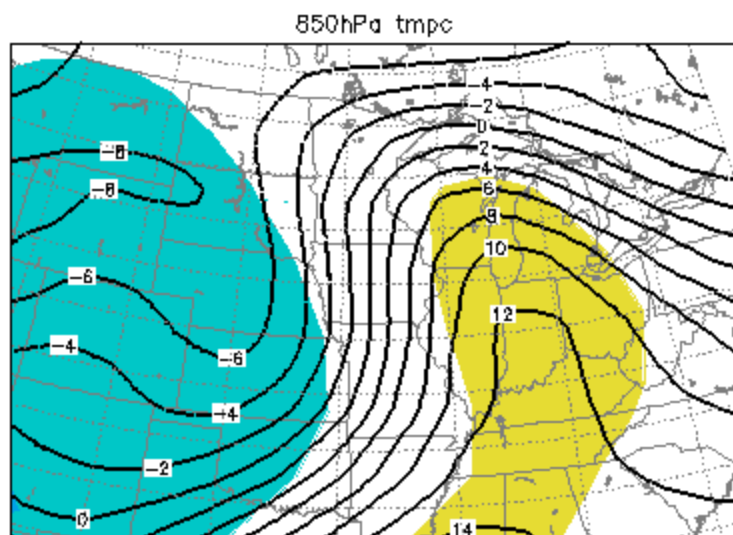
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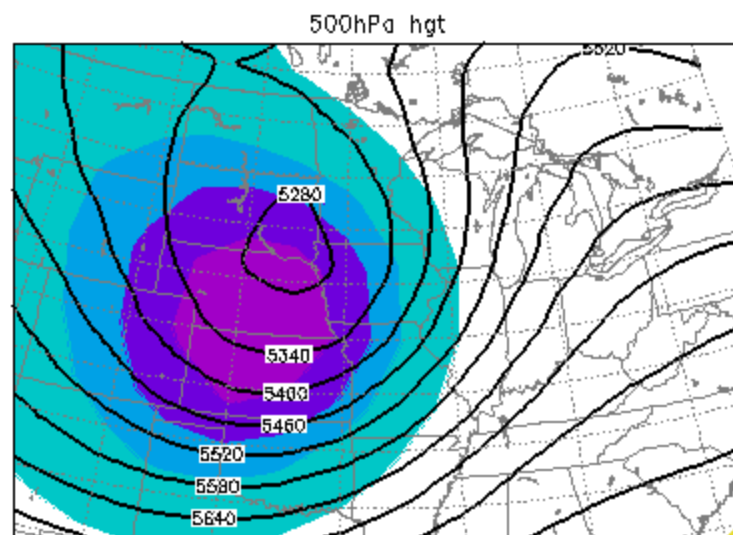
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Min: -4.73



Max: +2.58
Min: -1.98



Max: +1.58
Min: -2.15



Max: +1.18
Min: -3.43

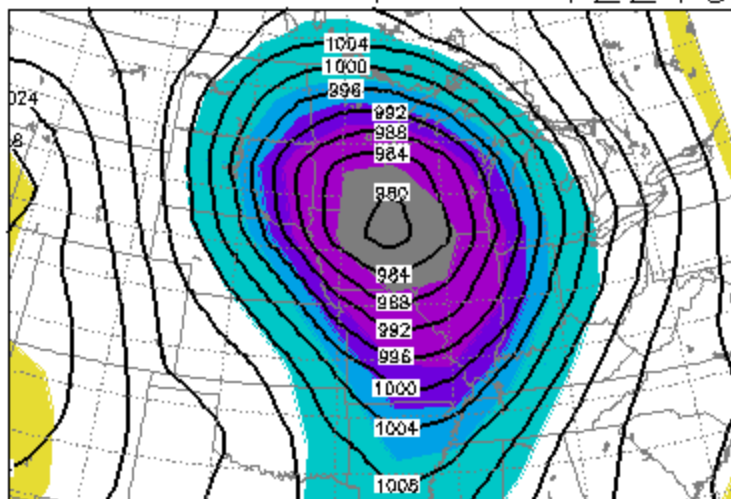
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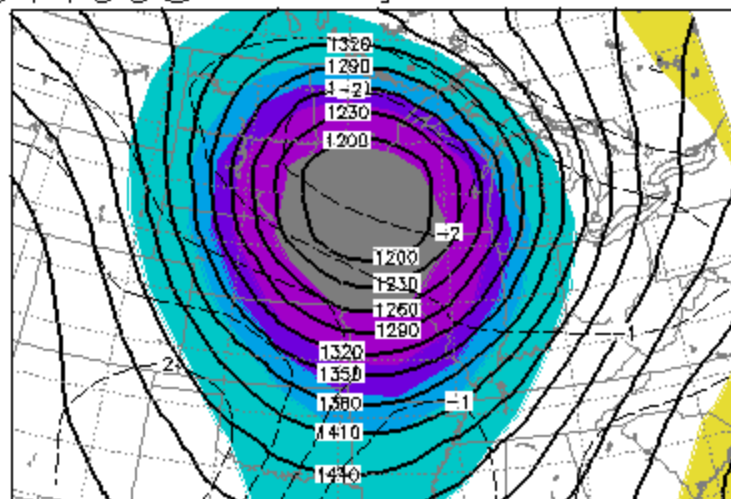
12Z10NOV1998

slp

850 hPa hgt and div



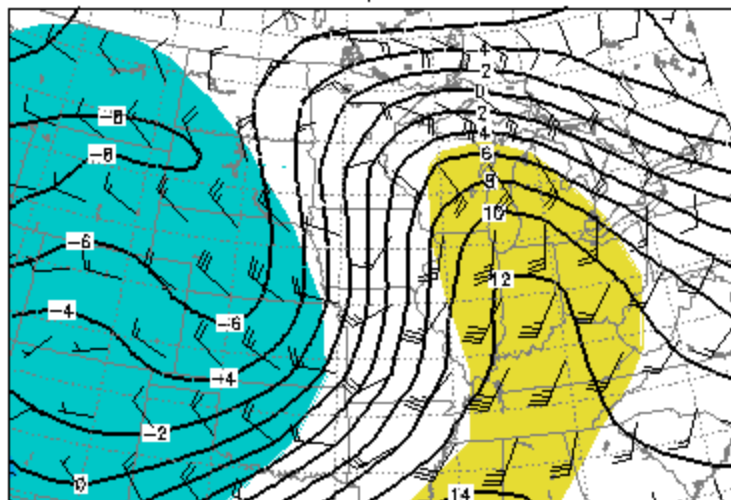
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Min: -4.73



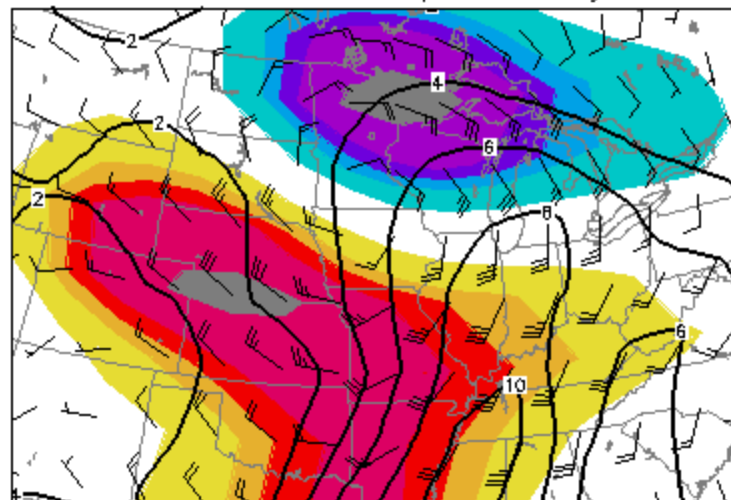
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Min: -5.05

850 hPa tmpc and winds

850 hPa u-wind and specific humidity



Max: +1.58
Min: -2.15

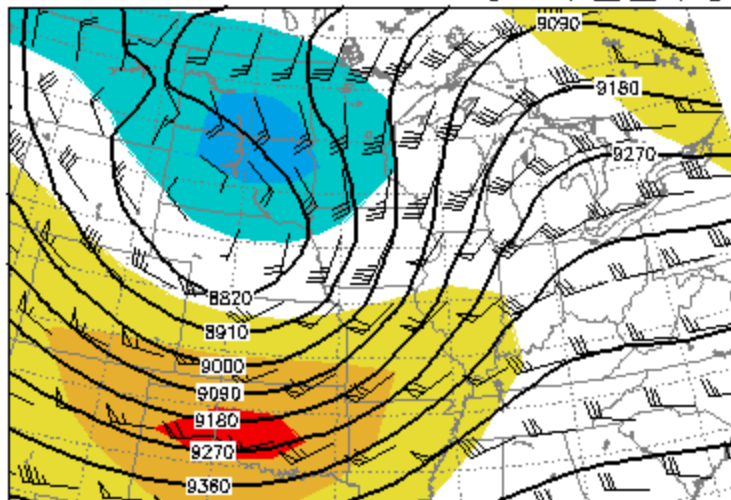


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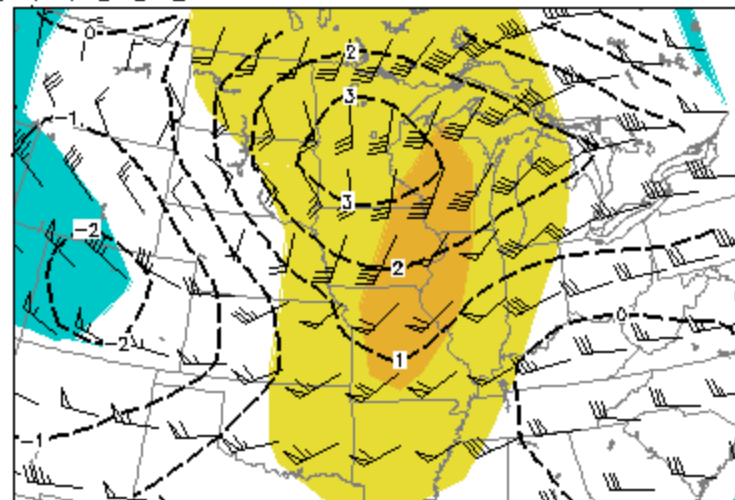
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300 hPa uwnd and hgt 12Z10NOV1998 300 hPa vnd and total div

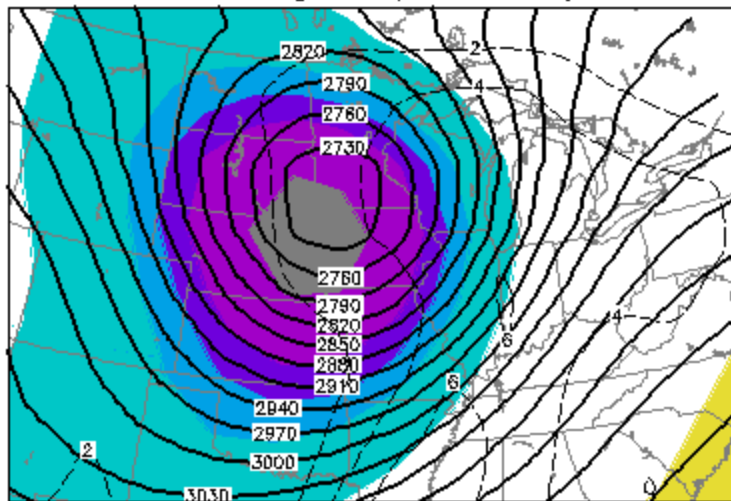


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Min: -2.36



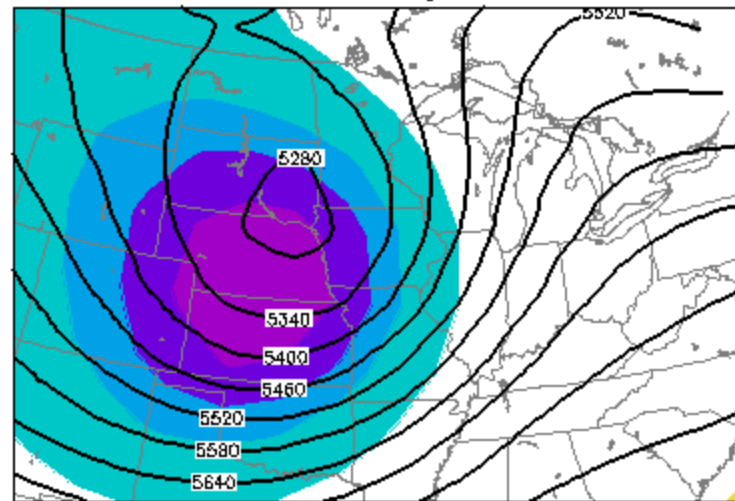
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700 hPa hgt and specific humidity



Max: +1.65
Min: -4.42

500 hPa hgt



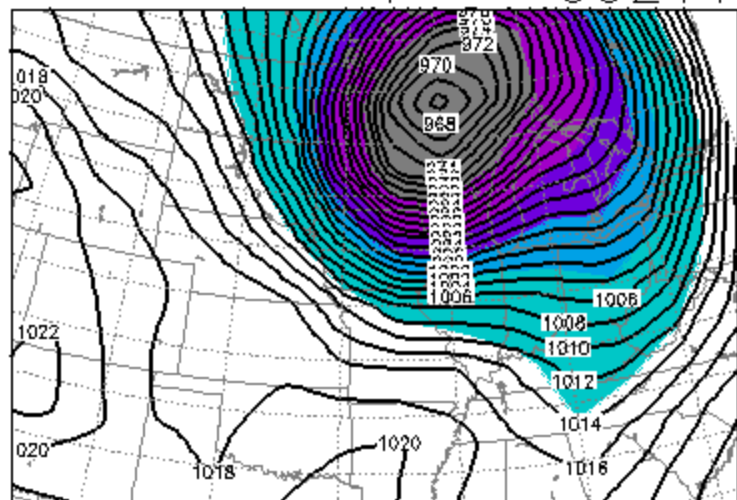
Max: +1.18
Min: -3.43

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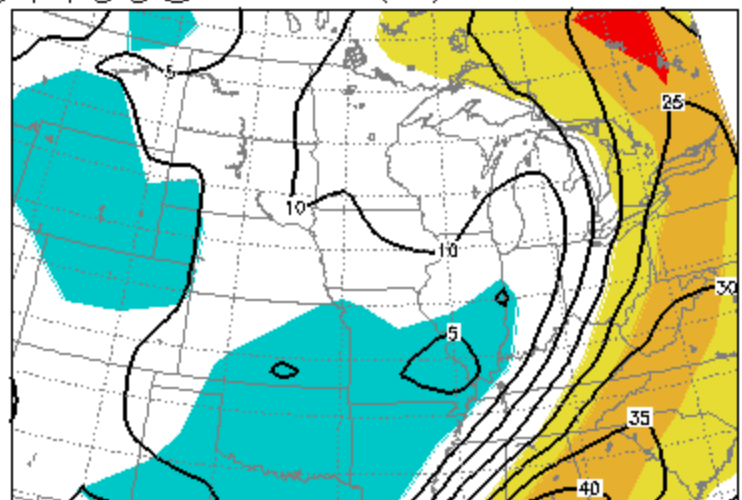
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mslp



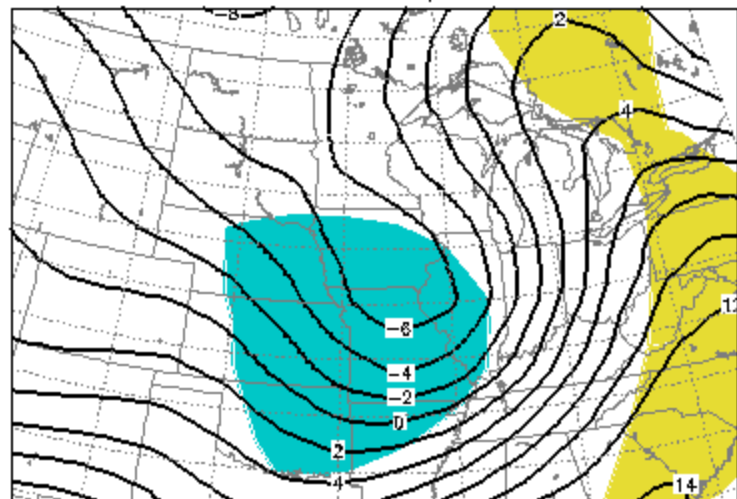
Max: +1.68
Min: -5.62

PWAT (mm)



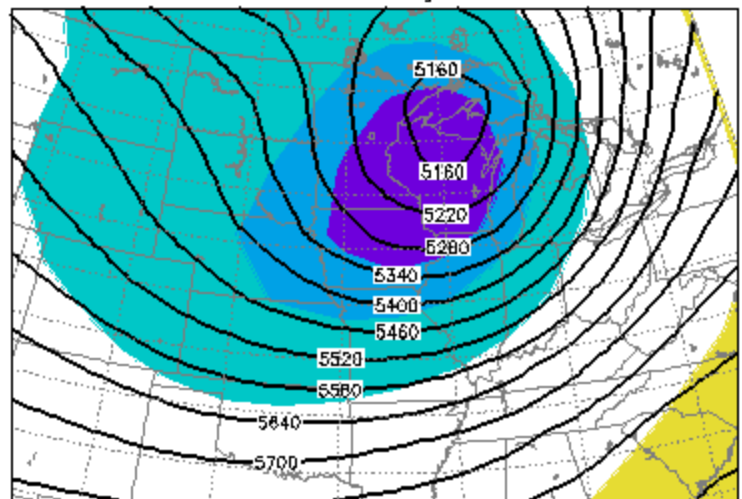
Max: +2.70
Min: -1.70

850hPa tmpc



Max: +1.31
Min: -1.54

500hPa hgt



Max: +1.61
Min: -3.00

0 August, 2002

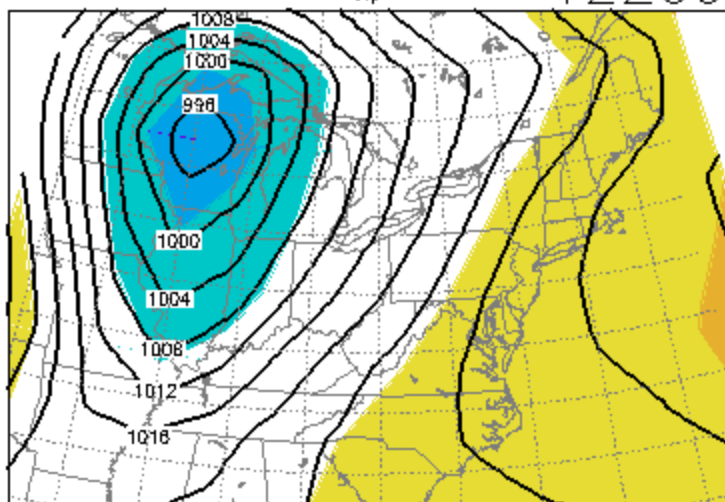
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Winter Wind Events

- **10 November 1998 record storm**
 - *\$40 million in damage IL,IA,KY,MI,MN and WI*
 - *large are winds ≥ 50 kts*
 - *not a top-ten November event!*
 - *But had a signal*
- **9 March 2002**
 - *the “big blow” & the State College WalMart Storm*
 - *winter storm with strong winds*
 - *killed people in Chicago on Saturday 9 March*
 - *incredible LLJ jet with +V wind anomaly*

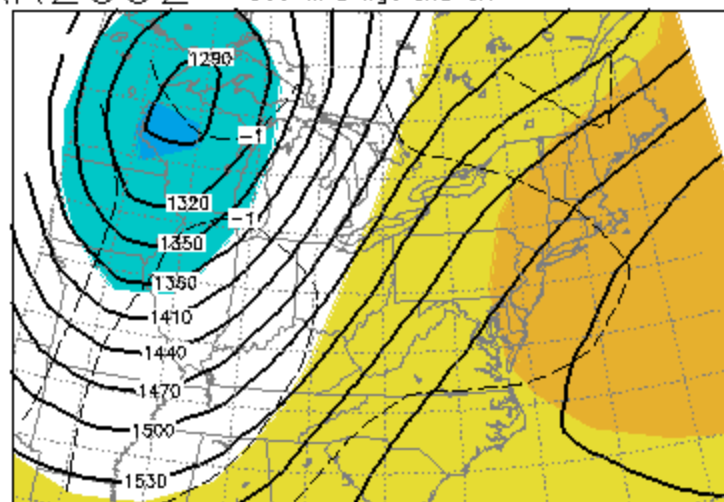
12Z09MAR2002

slp



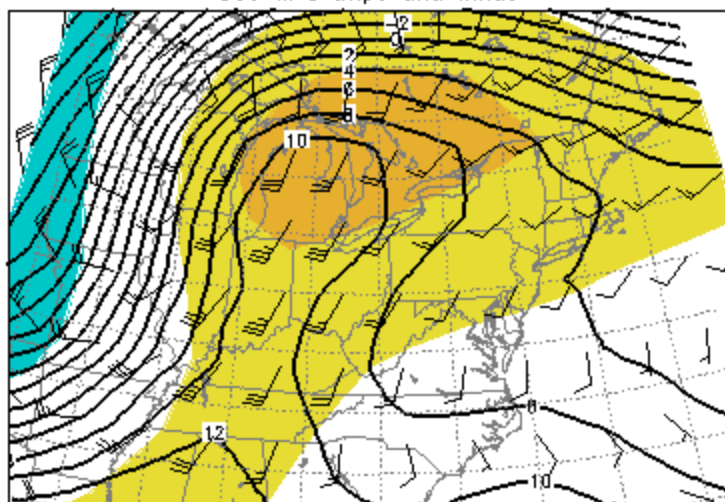
Max: +2.26
Min: -2.51

850 hPa hgt and div



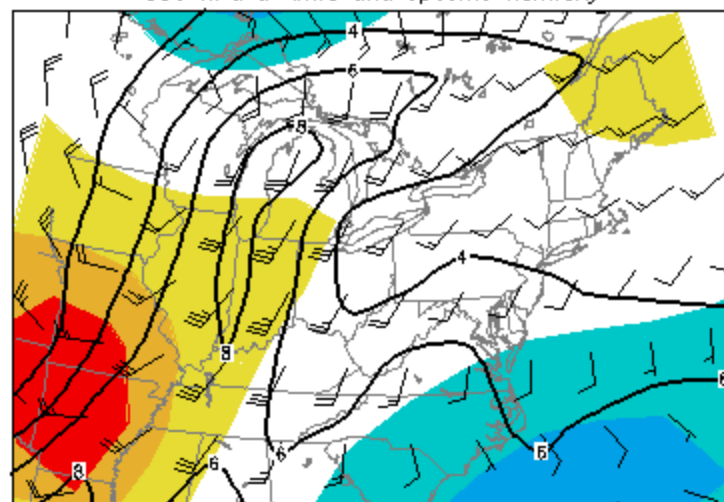
Max: +2.49
Min: -2.12

850 hPa tmpc and winds



Max: +2.46
Min: -2.05

850 hPa u-wind and specific humidity



Max: +2.90
Min: -2.43

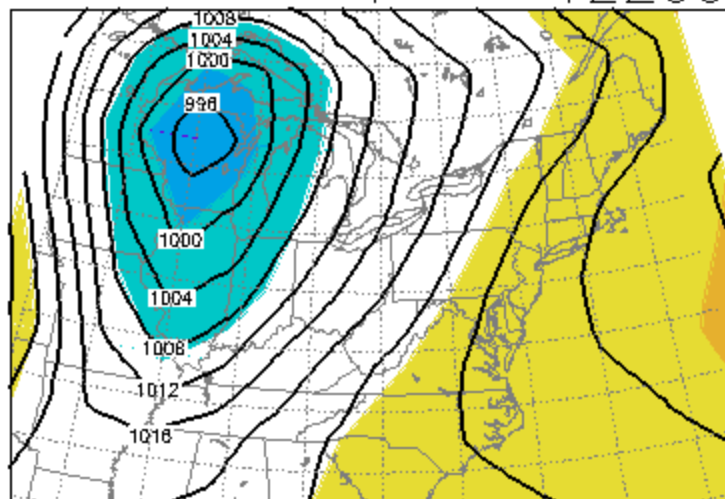
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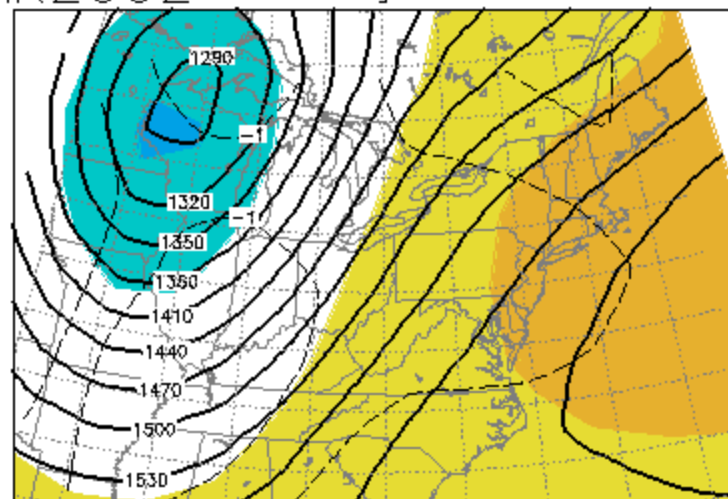
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slp

850 hPa hgt and div

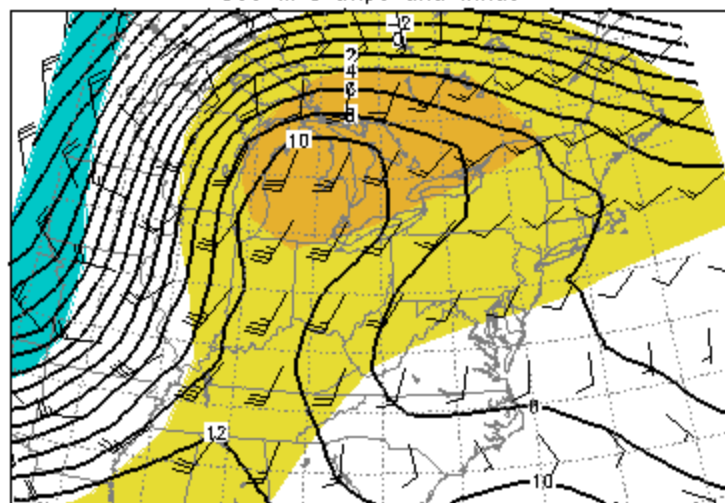


Max: +2.26
Min: -2.61



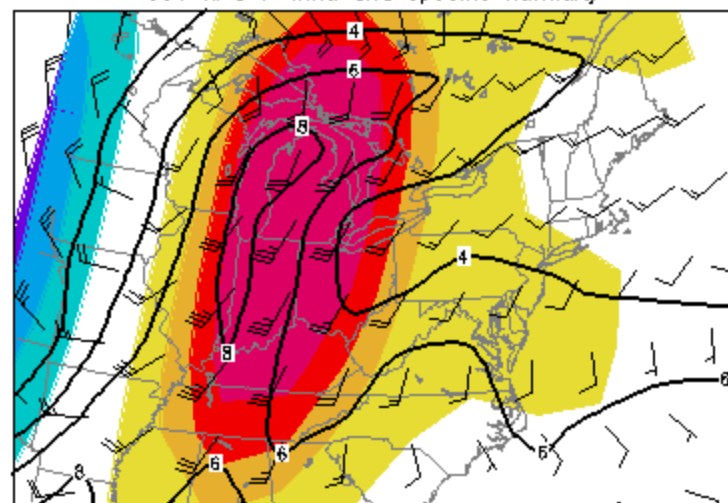
Max: +2.49
Min: -2.12

850 hPa tmpc and winds



Max: +2.46
Min: -2.05

850 hPa v-wind and specific humidity



Max: +3.96
Min: -2.69

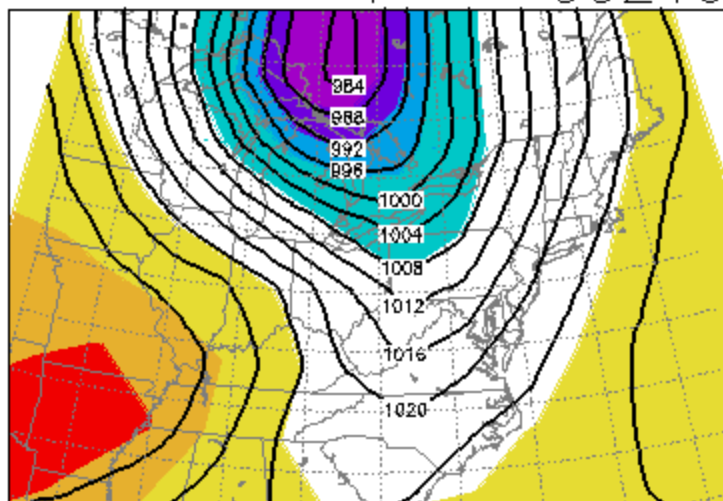
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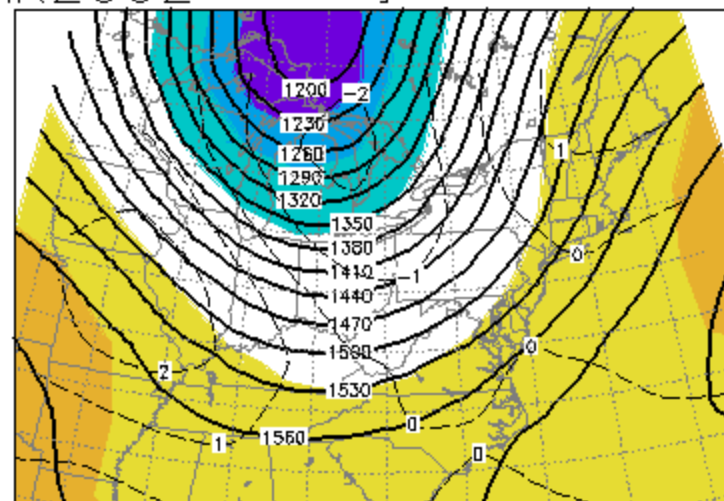
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850 hPa hgt and div

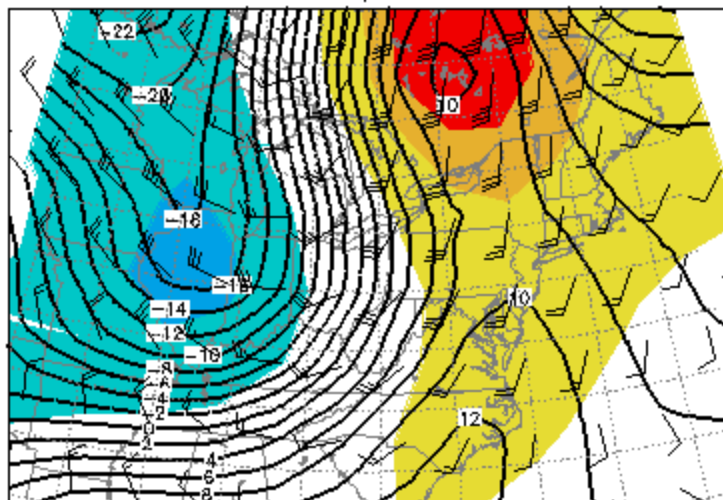


Max: +2.70
Min: -3.49



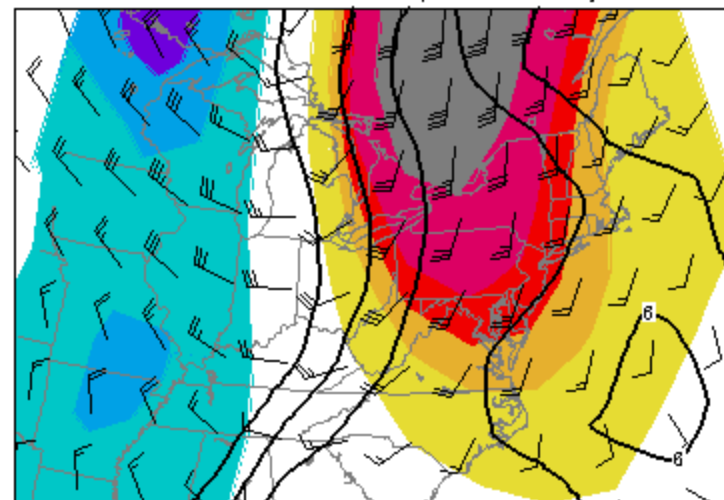
Max: +2.52
Min: -2.98

850 hPa tmpc and winds



Max: +2.94
Min: -2.26

850 hPa v-wind and specific humidity



Max: +5.34
Min: -2.76

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Conclusion

- **We defined a significant weather event**
 - *based on number of standard deviations from normal*
- **We learned to anticipate significant events:**
 - *$\sim N$ of 2 is normal for any given parameter*
 - *$\sim N$ of 0 is very rare*
- **There are different types of events**
 - *parameters seem to impact different events differently*
 - *snowstorm events*
 - *need easterly jet*
 - *deep low*

Conclusion

- **There are different types of events**
 - *parameters seem to impact different events differently*
 - *snowstorm event*
 - *need easterly jet*
 - *deep low*
 - *winter wind storms*
 - *need not be big MTOTAL events*
 - *deep low and deep upper level lows*
 - *anomalous winds (Big MWIND)*
- *Other points:*
 - *some recent success forecasting heavy rains and identifying heavy rain types (See WAF conference preprints 2002).*

Learning More

- **These data are free thanks to NCEP/NCAR**
 - *design study of event types*
 - *look for parameters that affect your area*
 - *determine anomalies associated with event types*
 - *climatological netCDF files are available.*
- **There is a lot to be done**
 - *we touched the tip of the iceberg*
 - *we did not look in the western US*
 - *great opportunity*
 - *We learned to anticipate significant events:*
- **Jump start your study:**

Jump start your study

- **Method with Indiana and Michigan**
 - **identify your events**
 - **make flat file:**
 - **00Z24JAN2000**
 - **12Z24JAN2000**
 - **12Z30DEC2000**
 - **email to richard.grumm@noaa.gov**
 - **perl script to make images**
 - **anomaly output for databases**
 - **if you find cool stuff, get the 60 GB dbms.**

References

- Hart, R.E and R.H. Grumm 2001: Using normalized Climatological anomalies to rank synoptic-scale events. *MWR*,**129**,2426-2442.
- Grumm,R.H, and R.E. Hart, 2001:Standardized Anomalies Applied to Significant Cold Season Weather Events: Preliminary Findings. *Wea.Fore.*,**16**,736-754.
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